A MANUAL OF ANÆSTHETIC TECHNIQUES

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BY

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WITH A FOREWORD BY THE LATE

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TO MY WIFE

PREFACE TO THE SECOND EDITION

THE changing specialty of anaesthesia has necessitated a fairly complete revision of the first edition. The chapter on ether has been brought up to date by Dr J R. Ritchie and a new chapter on Local Analgesia has been written by Mr S de C. Barclay

My thanks are due to the reviewers of the first edition for various suggestions for improvement and to the publishers for their consideration and co-operation

July 1958 W J PRIOR

PREFACE TO THE FIRST EDITION

THIS book is written with the idea of its being an anaesthetist s vade-mecum where he can look up any practical problems which confront him during the day-to-day administration of anaesthetics

It is written primarily for House Surgeons and Registrars commencing the practice of anaesthetics. No attempt has been made to delve deeply into the theory of anaesthesia the emphasis being on the practical techniques for the different types of operation

In anaesthesia it is practically impossible to prove statistically that one technique is better than another but with time one gets a clinical impression that one method in one s own hands gives better results than others As with many things it is the operator rather than his tools who really counts

In the Special Technique section where possible two tried methods have been included to allow the reader to choose that which suits him best

CONTENTS

Anæsthesia has made such rapid progress over the last few years that many text-books written only a short while ago are rapidly becoming out of date Many of the newer concepts and techniques have spread orally from one anæsthetist to another, or have appeared only in recent journals

An attempt has been made in this volume to include in one cover most of the important changes in recent years Mention has been made of artificial hibernation for the sake of completeness, but its final role in anæsthesia has yet to be worked out

Wherever possible the main references have been appended at the end of the appropriate chapter

The hope is that this may prove a useful standby in avoiding the many pitfalls which beset the aspiring anæsthetist and at the same time protect the patient from some of our major teething troubles

I wish to acknowledge my indebtedness to the Anæsthetists of the London Hospital from whom most of the techniques were learnt to Dr J R Ritchie, Dunedin, N Z, for his section on ether anæsthesia to Dr R H Orton of Melbourne and Dr C J J Morkane of Christchurch N Z To Sister J Turnbull of Christchurch Hospital Miss Marjorie Nelson for typing the manuscript and Mr A F Pope for the clinical photographs

W J PRYOR

December 1955

FOREWORD TO THE FIRST EDITION

By the late J. H. T. CHALLIS

Senior Anæsthetist, The London Hospital

THE art of Anæsthesia requires perfect technique to obtain the best results, and to teach such techniques is the principal object of this work.

Years ago there were very few anæsthetic agents and even less methods of administering them, but during the last twenty years or so the rate of increase of both has been very considerable. Some agents and techniques have not been long-lived, whereas others have proved their worth and are now of established use; it is with this latter group that this book is concerned, laying out in some detail only those which have withstood the test of time.

It is refreshing to have a book that really deals with the practical side of anæsthesia and does not wander unnecessarily into the realms of history, anatomy, physiology, etc. The subject is built up in a businesslike manner—first the workshop (the anæsthetic room), then the tools and equipment normally available and the raw materials usually employed, and then the main production, 'general anæsthesia', followed by short chapters on the more specialized methods and hazards, etc.

As stated by the Author, this book is written primarily for House Surgeons and Anæsthetic Registrars, but it has a much wider field, being indispensable as a quick reference for all anæsthetists embarking on a case which does not commonly come within their scope.

January 31, 1956

A MANUAL OF ANÆSTHETIC TECHNIQUES

CHAPTER I

THE ANÆSTHETIC ROOM

THE design of anæsthetic rooms has received much attention of recent years, particularly from Langton Hewer[1] in England

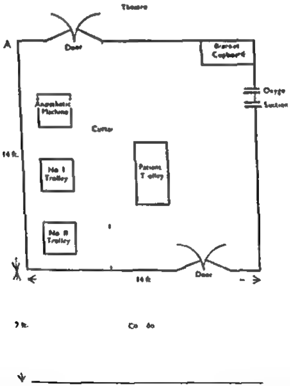

Fig 1.—Layout of anæsthetic room

The room itself should be regarded as the sanctum of the anæsthetist and as such should be quiet and isolated and of adequate dimensions The Ministry of Health[2] after

EQUIPMENT

An adequate establishment consists of the following —

1 **Anæsthetic Machine** —

On the Tray of the Machine (Fig 2) —

- A Mouth gag
- B Lubricant
- C Sponge holding forceps
- D Laryngoscope
- E Magill's forceps
- F Scissors
- G Sticking plaster

In the Drawer of the Machine —

Sphygmomanometer
Stethoscope
Head harnesses
Spanners

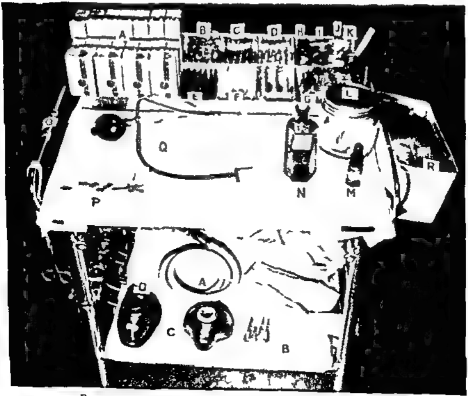

Fig 3 —Lay-out of top and lower shelves of No 1 trolley (see text)

consideration of the problem, recommended that the minimum area of an anæsthetic room serving one theatre should be 150 sq ft (14 sq m) and that the corridor outside should be at least 7 ft (2 1 m) wide so that trolleys can be turned easily into the door[3]. Ostlere[4] has suggested that anæsthetic rooms should be divided into two by a washable curtain, patients being wheeled into what appears to be an ordinary room After they have been induced with an intravenous barbiturate, the curtain is drawn back to make the anæsthetic machine available A specimen lay-out is shown in *Fig* 1

The doors are eccentrically placed to prevent the patient viewing the theatre as he is wheeled in It has also been suggested[5] that the ceiling of the anæsthetic room should be painted with some pleasing picture to encourage a tranquil state of mind in the patient as he lies on the trolley

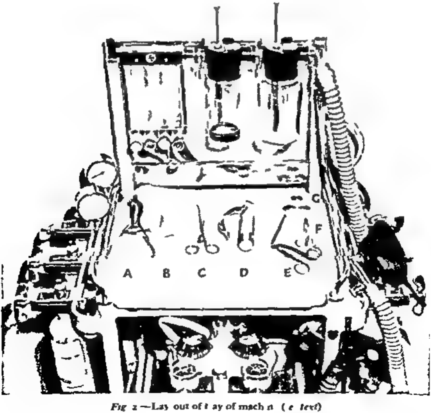

Fig 1—Lay out of tray of machine (see text)

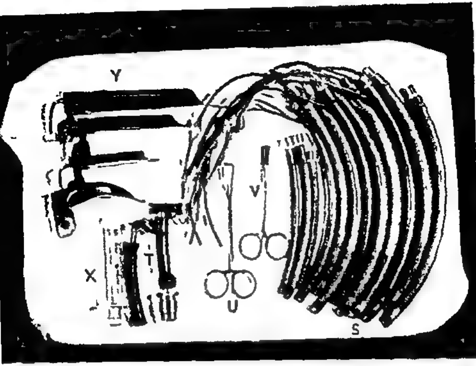

Fig 4 —Lay-out of middle shelf of No 1 trolley (*see text*)

No 2 Trolley (*Fig* 5) —

- A Funnel
- B Trilene
- C Ether drop bottles
- D Ethyl chloride
- E Ether
- F Schimmelbusch masks
- G Spare endotracheal tubes
- H Arm rest
- I Double harness holder

The Emergency Trolley* (*Fig* 6) —This should be kept fully equipped for such emergencies as drownings, electrocutions collapse and emergency bronchoscopies in the wards etc The practice of borrowing equipment from it should be discouraged, as the vital piece is sure to be missing when most required

* As recommended by Dr R H Orton of Melbourne Australia

2 No 1 Trolley —

Top Shelf (*Fig* 3) —

A Ampoules of thiopentone sodium
B Ampoules of gallamine triethiodide
C Ampoules of d tubocurarine chloride
D Ampoules of suxamethonium
E Ampoules of neostigmine methylsulphate
F Ampoules of atropine sulphate
G Ampoules of stimulants and vasopressor agents
H Files
I 4 per cent lignocaine hydrochloride
J Container for large-bore mixing needle, Gordh's needles, etc
K Forceps
L Container for sterile swabs (coloured green to distinguish them from the surgeon s)
M Paraffin drops
N Spirits Vini Meth
O Catheters and tourniquets
P Plastic syringe stand
Q Macintosh s syringe
R Side container for empty cartons, ampoules, etc

Lower Shelf (*Fig* 3) —

A Sucker tubing
B Autoclaved syringes and needles for intravenous thiopentone relaxants etc
C Face masks
D Airways

Middle Shelf (*Fig* 4) —

S Endotracheal tubes
T Endotracheal adapters
U Tongue forceps
V Spencer Wells forceps (for clipping cuffed tubes)
X Syringe (for inflating cuffed tubes)
Y Spare laryngoscope blades

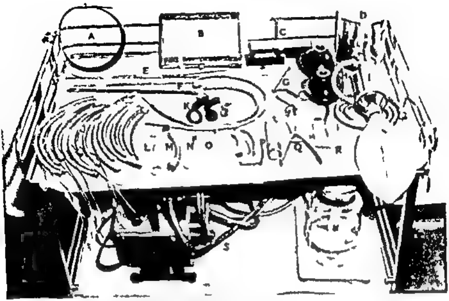

Fig 6—Lay out of emergency trolley (*see text*)

E Endobronchial suckers
F Bronchoscopes
G Magill's forceps
H Face masks
I Waters canister and bag
J Endotracheal tubes
K Airways
L Tongue forceps
M Endotracheal adapter
N Spencer Wells forceps (for clipping cuffed tubes)
O Syringe (for inflating cuffed tubes)
P Laryngoscope
Q Mouth gag
R Lubricants

Bottom Shelf —

S Portable suction unit

The Anæsthetic Cupboard—Here can be kept all spares, and those pieces of apparatus which are not in constant use It need not be in the anæsthetic room but should be reasonably accessible in the theatre block

Fig. 5.—Lay out of No. 2 trolley (see text)

The following is a list of equipment required —

Top Shelf —

- A Negus eye shield
- B Tracheotomy set
- C Spare batteries
- D Soda lime

Oxygen and Suction.—The anæsthetic room should be fitted with an oxygen supply, which in most modern hospitals comes from a central battery of cylinders. From here it is piped to each anæsthetic room, which has a flowmeter fitted to the wall, and allows of flows of up to 10 litres per minute.

Similarly there should be some means of aspirating the patient, either pre- or post-operatively. Usually a wall suction apparatus is provided.

Trolleys.—The design of the patient's trolley is important. It should be long enough for the tallest patient, and run smoothly on four swivel wheels to allow of side-to-side as well as forward movement. The foot of the trolley should be able to be raised in case the patient vomits during induction. With those trolleys which can only be raised at one end, it is important to see that the patient is the right way round before induction.

Resuscitation Room.—Where space permits it is a good idea to set aside one room for resuscitation cases. The intravenous trolley can be kept here, as well as heat cradles, resuscitators and the emergency trolley, oxygen supply, and suction apparatus.

It can serve not only theatre cases, but emergency cases admitted from the casualty department.

Recovery Ward.—In the larger hospitals a recovery ward staffed by specially trained personnel serves a useful purpose. Ruth, Haugen, and Grove[6] analysed 307 deaths associated with anæsthesia and found that half of these were preventable. Furthermore 63 per cent of deaths in the preventable group were due to inadequate nursing care post-operatively and were caused by respiratory obstruction. The authors strongly advocated the use of a post-operative recovery ward.

Particularly now, with the use of relaxants, the return of a patient to a busy surgical ward does not give the anæsthetist the same peace of mind as if that patient were returned to a smaller ward where the whole-time duty of the staff is to watch the patient until there is full recovery from the anæsthetic.

Organization.—The recovery ward should be as near the operating theatre as possible, and the responsibility for the

The following is a representative, but by no means comprehensive, list of the contents of the anæsthetic cupboard —

I Infants endotracheal tubes (some armoured)
II Endotracheal spares, T-tubes, etc
III Spare rubber tubing and face masks
IV Sphygmomanometer and stethoscope
V Children s CO_2 absorption units
VI Spare cuffed and uncuffed tubes
VII Laryngeal sprays
VIII Pharyngeal airways and masks
IX Waters canisters
X Spare bags and harnesses

Intravenous Trolley —It is usually more convenient to have all the requirements for intravenous therapy contained on one trolley, which should have the following —

I Assorted needles and cannulæ
II Cutting down set
III Two giving sets
IV Sterile receiver
V Two sterile bowls
VI An arm rest
VII Tourniquets
VIII 2 in and 3 in bandages
IX ½ in and 1 in strapping
X Container of sterile swabs
XI 500-ml bottles of normal saline
XII 500 ml bottles of distilled water
XIII 500 ml bottles of isotonic sodium citrate
XIV 500 ml bottles of 5 per cent glucose in normal saline
XV 500 ml bottles of 4 3 per cent dextrose in 1/5 *N* saline (Bart s solution)
XVI 500-ml bottles of plasma substitutes

CHAPTER II

EQUIPMENT

1 FACE MASKS

These consist of a moulded rubber body, with an inflatable rubber pad around the lower edge, designed to fit the contours of the face (*Fig* 7) There are usually four sizes infants, small, medium, and large

Fig 7 —Face mask ordinary pattern (British Oxygen Gases Ltd)

Fig 8 —Goitre face mask (British Oxygen Gases Ltd)

patient should be shared by surgeon and anæsthetist [5] Two beds should be available for each theatre and there should be a permanent, fully trained Sister in charge The essential equipment consists of oxygen and suction apparatus, intravenous equipment, sphygmomanometer, laryngoscope, endotracheal tubes, and some method of applying intermittent positive pressure with oxygen to the patient

Advantages—There is economy in the use of equipment and nursing staff and the patient recovering from his anæsthetic is not in full view of other ward patients, some of whom may be about to have their operations Jolly and Lee[7] have recently reported favourably on a year's trial of a post-operative ward at their hospital

REFERENCES

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[2] MINISTRY OF HEALTH HOSPITAL BUILDING BULLETIN OPERATING THEATRE SUITES 1957 26
[3] WARD R *Design and Equipment of Hospitals* 1949 213 London Baillière Tindall & Cox
[4] OSTLERE G *Anæsthesia* 1950 5 91
[5] HEWER C LANGTON *Brit med J* 1955 2 257
[6] RUTH H S HAUGEN F P and GROVE D D *J Amer med Ass* 1947 135 881
[7] JOLLY C and LEE J A *Anæsthesia* 1957 12 49

2 HEAD HARNESSES

a **The Clausen Harness** (*Fig* 11)—Consists of an adjustable rubber headband with three straps attaching to a metal ring and hooks, which fits over the face mask

Fig 11—The Clausen harness (British Oxygen Gases Ltd)

b **The Connell Harness** (*Fig* 12)—Consists of a rubber headband with four rubber tension adjusters, which pass in pairs through two combined hooks and grips The hooks are attached to metal studs screwed into the face mask

Fig 12—The Connell harness (British Oxygen Gases Ltd)

Goitre Face Mask (*Fig* 8) —Consists of a modification of the above with the breathing tube mount fitted to the body at a position above the nose leaving a clear field for the surgeon

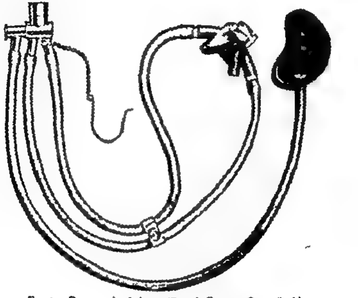

Fig 9 —Oro-nasal inhaler (British Oxygen Gases Ltd)

Nasal Masks —For use in dental anæsthetics Two types are in common use —

a Nasal Inhaler (*Fig* 9) —Consists of a moulded rubber nose-piece to which is attached an adjustable, lever-type expiratory valve A double rubber tubing leads to a metal mount which can be inserted into the corrugated tubing of the machine

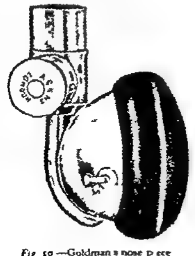

Fig 10 —Goldman's nose piece (British Oxygen Gases Ltd)

b Goldman's Nose-piece (*Fig* 10) —Consists of a metal body with a removable rubber pad round the edge It is kept in position by a light head harness and there is a Heidbrink expiratory valve located on one side of the breathing tube mount The advantage is that it leaves the anæsthetist's hands free to control the patient's airway

c **Waters** (*Fig* 16)—This is a similar shape to the Guedel, but in metal, and therefore liable to cause more trauma

Fig 16—The Waters airway (British Oxygen Gases Ltd)

d **London Hospital Mouth Prop** (*Fig* 17)—In metal, and inserted between the incisor teeth to protect the end of an endotracheal tube from being bitten It is liable to chip the teeth if the patient comes light and clenches his jaw

Fig 17—The London Hospital airway mouth prop (British Oxygen Gases Ltd)

e **Plastic Airways**—The drawback to the first three types of airway has been the difficulty in cleaning the interior An attempt has recently been made to overcome this difficulty by producing airways (usually in plastic) with a median bar and open grooves on each side to allow of easier cleaning

4 GAGS AND MOUTH PROPS

a **Ferguson's Gag** (*Figs* 18, 19)—This has a simple type of ratchet lock which can be operated by the thumb and forefinger of the hand holding the gag There are two models, one with ordinary jaws (one above the other) (*Fig* 19 A) and one with Ackland jaws (in the same plane) (*Fig* 19 B) The latter is easier to insert between the teeth Both should have rubber tubing fitted over the jaws to prevent trauma

c **The Hudson Harness** (*Fig* 13) —For use in endotracheal anæsthesia

Consists of a slotted rubber strap with a stud fixing for tension adjustment The endotracheal connexion is firmly gripped by the band, and drag on the tube is prevented

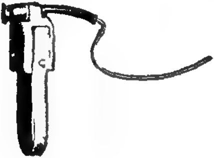

Fig 13 —The Hudson harness (British Oxygen Gases Ltd)

3 AIRWAYS

a **Phillips** (*Fig* 14) —Consists of a rubber airway with a metal mount It provides a good airway, but the metal mount can cause trauma to lips and gums if the face mask is firmly applied

Fig 14 —The Phillips airway (British Oxygen Gases Ltd)

b **Guedel** (*Fig* 15) —A moulded rubber airway with a metal insert at the oral end It is tolerated at lighter levels of anæsthesia than the Phillips It does not give as free an airway at times as the pharyngeal opening may become partially occluded by the pharyngeal wall

Fig 15 —The Guedel airway (British Oxygen Gases Ltd)

d **'Devonshire' Props** (*Fig* 21)—Consist of a rubber wedge with deep corrugations on each biting surface to prevent slipping They are less traumatic than Mushin's props

Fig 21 — Devonshire dental props (British Oxygen Gases Ltd)

5 ENDOTRACHEAL APPARATUS

a **Magill's Tubes** (*Fig* 22)—

1 *Uncuffed*—These are curved rubber tubes designed for introduction into the trachea The oral tubes are made in various sizes from the smallest (00) to the largest (12) The nasal tubes (having thinner walls) are made in sizes 2–8 All sizes have the same curve ($7\frac{3}{4}$ in radius), and are constructed with the bevel cut on the right when viewed from the concave aspect

Fig 22—Uncuffed Magill tube (British Oxygen Gases Ltd)

Sterilization of tubes—

α Boil for no longer than 2 minutes with the metal connexions removed or

β Wash in cetavlon clean and immerse in 1–1000 biniodide or 70 per cent alcohol for 2 3 hours Dry and store in a circular tin to maintain their curve

b **Mason's Gag** —Is similar to Ferguson's, but with a screw locking device Both these gags are made in two sizes, adult and child

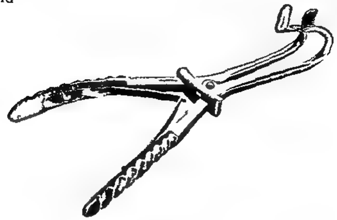

Fig 18 —The Ferguson gag (British Oxygen Gases Ltd)

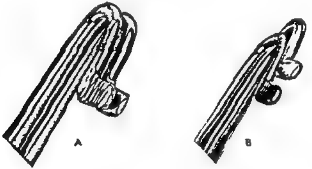

Fig 19 —The jaws of the Ferguson gag A Ordinary pattern B Ackland jaws (British Oxygen Gases Ltd)

c **Mushin's Dental Props** (*Fig* 20) —Consist of a series of four metal props with removable rubber pads inserted into a channel in each end

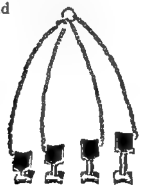

Fig 20 —Mushin dental props (British Oxygen Gases Ltd)

part of its length. Useful for children, as they are less likely to kink, and prevent the smaller tube from slipping down into the right bronchus

How to gauge the Size of Tube to use—

Length The length of the tube should be approximately double the length from the lobe of the ear to the base of the naris

Gauge

Infants

0–3	months	- -	Size OO
3–6	„	- -	„ O
6–9	„	- -	„ OA
9–12	„	- -	„ 1
12–15	„	- -	„ 2

Children

A rough guide is— $\dfrac{\text{Age in years} + 1}{2}$

i e, a 5-year-old will take a size 3 and so on

Adults

Women	- -	Size 7–9
Men	- -	8–10

DIMENSIONS AND CATHETER GAUGE EQUIVALENTS OF MAGILL ORAL AND NASAL TUBES

Oral	Nasal	Approx External Diameter	Approx Internal Diameter Oral	Approx Internal Diameter Nasal	Length	Nearest French Catheter Gauge
		in	in	in	in	
00	—	[illegible]	—	—	8	13
0	—	[illegible]	[illegible]	—	$8\frac{1}{2}$	16
1	—	$\frac{1}{4}$	—	—	$8\frac{3}{4}$	19
2	2	[illegible]	[illegible]	—	$9\frac{1}{4}$	21
3	3	—	—	—	$9\frac{3}{4}$	24
4	4	[illegible]	—	[illegible]	$10\frac{3}{8}$	25
5	5	[illegible]	—	—	$10\frac{7}{8}$	27
6	6	$\frac{3}{8}$	—	[illegible]	$11\frac{3}{8}$	29
7	7	—	—	—	$12\frac{3}{8}$	31
8	8	[illegible]	[illegible]	—	13	33
[illegible]	—	$\frac{1}{3}$	—	—	$13\frac{3}{8}$	36
10	—	$\frac{1}{2}$	—	—	$14\frac{1}{4}$	38

ii *Cuffed* (*Fig* 23).—These are oral tubes made in sizes 3–10, and incorporate an inflatable cuff at the distal end, to ensure an air-tight fit in the trachea. Leading from the cuff is a small side tube with a pilot balloon at the proximal end, to enable the anæsthetist to gauge the degree of inflation of the cuff.

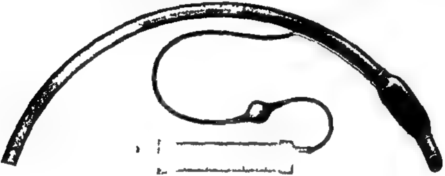

Fig 23.—Cuffed Magill tube (British Oxygen Gases Ltd.)

The tube is inserted until the cuff is beyond the cords, and is then inflated with a syringe. The side-tube may incorporate a non-return valve or it can be clamped off with forceps.

iii *Portex*.—Have thicker walls and are less liable to kink than the ordinary tubes. They are useful in neurosurgical and E.N.T. anæsthesia. They must not be boiled to sterilize or they lose their shape.

iv *Flexo metallic* (*Fig* 24).—Consist of a flexible rubber-covered wire-coil tube with an all-rubber tip. Used for cleft-palate operations in children and in neurosurgery.

Fig 24.—Flexo metallic tube (British Oxygen Gases Ltd.)

v *Reinforced* (*Fig* 25).—Consist of a standard oral Magill tube contained within another of larger size, for the greater

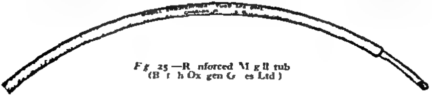

Fig 25.—Reinforced Magill tube (British Oxygen Gases Ltd.)

iv Ayre's *T-piece* (*Fig* 29)—Used for endotracheal anæsthesia in infants and children The endotracheal tube is attached to one limb and an open ended piece of rubber

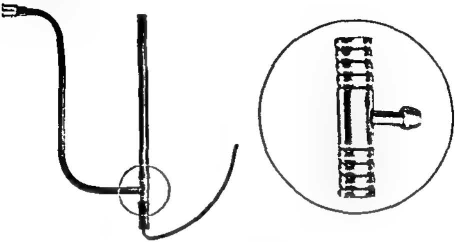

Fig 29—Ayre's T piece (British Oxygen Gases Ltd)

tubing (4–10 in in length) to the other This serves as a rebreathing bag and resistance in the circuit is negligible The gas-supply is attached to the third limb There are two sizes 1 and 2

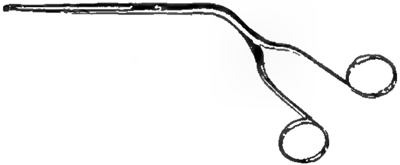

Fig 30—Magill's forceps (British Oxygen Gases Ltd)

v *Magill's Forceps* (*Fig* 30)—Used for guiding endo tracheal tubes under direct vision or for packing the pharynx The handles are curved, so the anæsthetist's hand does not obstruct his view Made in adult and child sizes

b Endotracheal Connexions and Adapters —

i *Magill's Connexions* (*Fig* 26) —For joining the endotracheal tubes to the anæsthetic supply The nasal connexions have a sharper curve than the oral ones They have less resistance to gas flows, but are more likely to slip out of the tubes than the Rowbotham Sizes Oral 1–6a Nasal 7–12

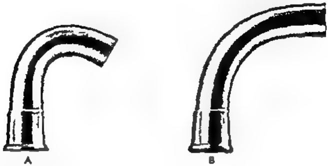

Fig 26 —Magill tube connexions A Nasal B Oral (British Oxygen Gases Ltd)

ii *Rowbotham's Connexion* (*Fig* 27) —This is a right angled connexion with a serrated and tapered limb for insertion into the endotracheal tube It is made in four sizes (1–4) and grips the tube firmly but owing to turbulence (*see* p 29) presents more resistance to flow of gases

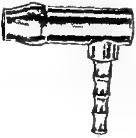

Fig 27 —Rowbotham connexion *Fig* 28 —Cobb suction union
(British Oxygen Gases Ltd)

iii *Cobb's Suction Union* (*Fig* 28) —Is a modification of Rowbotham's connexion with a removable plug to allow the insertion of a suction catheter into the lumen of the tube Made in three sizes 2 3 and 4

blade the other The tip of the blade lifts the epiglottis forwards to expose the cords A folding pattern is also produced and the blades are in three sizes, infant, child and adult

ii *Macintosh's* (*Fig* 34)—Here the blade is curved and L-shaped in cross section The tip is thickened and is meant to lie between the base of the tongue and the epiglottis When the base of the tongue is lifted forwards, the epiglottis is lifted forwards with it, and exposes

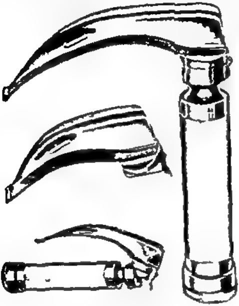

Fig 34—Macintosh's laryngoscope (British Oxygen Gases Ltd)

Fig 35—The Shadwell blade for laryngoscopy in infants (British Oxygen Gases Ltd)

the cords to view Adult and child size blades are made This laryngoscope is easier to introduce for the beginner, and can be used at a lighter level of anæsthesia

iii *Infants'*—For infants a small Magill blade or one of the Shadwell design (*Fig* 35) is probably the easiest to use

d **Laryngeal Sprays**—

Macintosh's (*Fig* 36)—Consists of a moulded rubber bulb to which a plastic container (4 ml) is attached by a rubber tube The nasal spray nozzle consists of two rubber tubes arranged concentrically with a vulcanite jet at the free end The oral tube has a flexible wire incorporated so it may be curved in any direction The latter enables the whole

vi *Bourne's Spring* (*Fig* 31)—A flexible metal tube used to prevent kinking of the endotracheal tube in the pharynx, especially in neurosurgical anæsthesia It is liable to cause trauma to the pharynx

Fig 31—Bourne's spring
(British Oxygen Gases Ltd)

vii *Gum-elastic Suction Catheter* (*Fig* 32)—This is passed down the endotracheal tube to carry out tracheobronchial toilet at the end of the operation

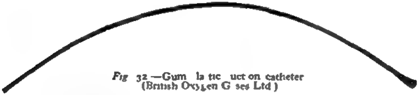

Fig 32—Gum-elastic suction catheter
(British Oxygen Gases Ltd)

c **Laryngoscopes** (*Figs* 33–35)—

i *Magill's* (*Fig* 33)—Made in the form of a U, with the handle containing batteries forming one limb, and a straight

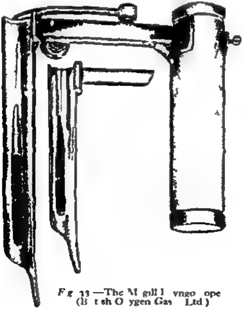

Fig 33—The Magill laryngoscope
(British Oxygen Gases Ltd)

b **Mitchell's** (*Fig* 38)—Consists of a hollow needle with its opening at one side near the tip A rubber covered metal

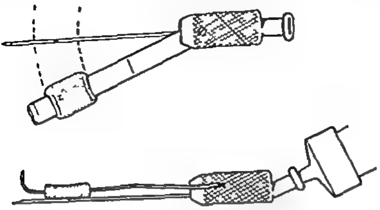

Fig 38—Mitchell's needle (Vann Bros Ltd)

spring is made to swivel across this opening and occlude it by pressing it against vein wall and skin, forming a non-return valve

7 DOUBLE HARNESS HOLDER

A piece of four-ply wood cut to the dimensions below and placed beneath the mattress of the operating table, is useful to

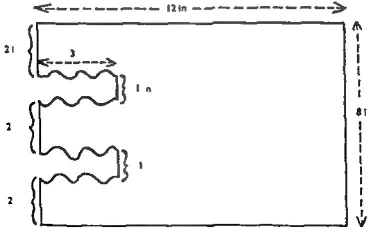

Fig 39—Double harness holder

take the weight of the double harness from the machine The rubber tubing is gripped in the grooves and prevents drag on the patient (*Fig* 39)

trachea to be sprayed as far as the carina The one disadvantage of this spray is that it is rather temperamental and requires constant servicing

In a recent modification the oral tube is in metal, curved so as to be easily introduced into the trachea

Fig 36—The Macintosh spray (B it h O yg n Ga es Ltd)

6 NEEDLES FOR INTRAVENOUS INJECTIONS

a **Gordh's** (*Fig* 37) —Consists of a flanged needle with a rubber diaphragm at one end It is inserted into a vein and the slight positive pressure from the diaphragm prevents blood entering the needle and clotting Injections are given with a hypodermic needle through the diaphragm

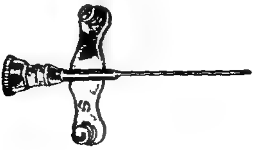

Fig 37—(o dh n dl (Brit h yg n Co I td)

room temperatures A 'full' cylinder is nine tenths liquid and one tenth gas, hence the cylinder cannot be used lying flat, or liquid nitrous oxide will escape For the same reason a pressure gauge gives no indication of the amount of gas in the cylinder, as the pressure does not start to fall until all

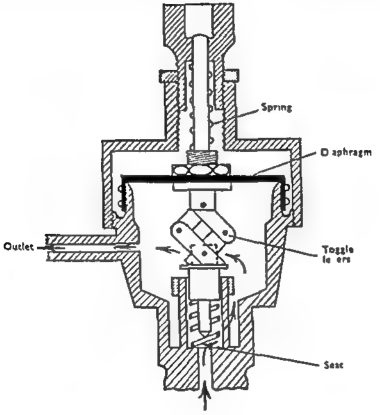

Fig 40 —Diagram of the Adams valve.

the liquid has volatilized The standard sized cylinders contain 200 gallons (909 litres) and are painted dark blue

Carbon Dioxide The standard cylinders contain approximately 4 lb by weight of carbon dioxide as a liquid at a pressure of 750 lb /sq in They are coloured grey

Cyclopropane These cylinders are smaller 20-gallon (91 litres) and 100 gallon capacity and the gas is liquefied at room temperatures The pressures are much lower (80–90 lb /sq in), and consequently no reducing valve is required,

CHAPTER III

MECHANICAL AND PHYSIOLOGICAL ASPECTS OF ANÆSTHESIA

INTRODUCTION

A COMPETENT anæsthetist must have a sound knowledge of the mechanics of his machines and the physiology of his patients He must know the minute to minute requirements of the latter, and how to supply them by means of the former I have on more than one occasion seen a trainee anæsthetist supplying an adult patient with a total flow rate of four litres of gases on a semi open circuit and seem at a loss to explain the patient s resulting hyperpnœa A basic knowledge of the patient s minute volume requirements would have solved the problem for him

In this chapter a few of the practical aspects will be discussed Those wishing to delve more deeply into the physics of anæsthesia are recommended to read *Physics for the Anæsthetist* by R R Macintosh and W W Mushin *

Gases used in Anæsthesia —The commonly used gases, nitrous oxide, oxygen cyclopropane and carbon dioxide, are prepared by the various industrial firms and compressed into cylinders for use in anæsthesia

Cylinders —

Oxygen This is compressed at 1800–2000 lb /sq in and does not liquefy at room temperatures Hence the pressure gauge which is usually attached gives a reasonably accurate estimate of the amount of gas in the cylinder The standard size for use in hospital machines contains 70 gallons (318 litres) By international convention the cylinders are painted black with white shoulders

Nitrous Oxide The pressure of the nitrous oxide cylinders is approximately 750 lb /sq in and the gas is liquefied at

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* Published by Blackwell Oxford

1 Fluids flow along tubes only when there is a pressure gradient between the ends, i e, from the high-pressure to the low-pressure region

2 The volume flow rate through a straight tube of uniform bore is directly proportional to the pressure gradient within it

3 The volume flow rate is directly proportional to the fourth power of the diameter (law of Hagen and Poiseuille)[1,2]

4 The volume flow rate varies inversely with the viscosity of the fluid *N B* $\frac{\text{Viscosity of Oxygen}}{\text{Viscosity of Cyclopropane}} = \frac{2 \cdot 1}{1}$

Laminar and Turbulent Flow —When a fluid moves along a smooth tube the molecules move parallel to the sides of the tube, i e, the flow is *laminar* If the flow is irregular and broken up, it is termed *turbulent*

Laminar Flow becomes Turbulent —

a At high rates of flow i e above the critical flow rate' for that tube

b As a result of irregularities in the tube, e g, constrictions and sharp corners

With laminar flow the pressure drop or resistance is directly proportional to the flow rate, whereas with turbulent flow the resistance varies as the square of the flow rate

Practical Applications —

1 With normal gas flows the critical flow rate' is not exceeded and turbulence does not occur from this cause

2 Sudden changes in diameter of gas tubing may cause turbulent flow

3 Curved Magill endotracheal connexions are preferable to right-angled Rowbotham connexions for the same reason

4 Endotracheal tubes used should be the largest the patient can tolerate to reduce resistance in the circuit

5 The corrugated rubber tubing from the machine to the patient s mask is of very wide bore for the same reason

6 In intravenous work doubling the bore of the needle allows 16 times the amount of fluid to pass through it in the same time with the same pressure on the plunger

The Flow of Fluids through Orifices —Here the flow is partly turbulent, and density rather than viscosity determines

the gas passing straight to the flowmeters (1 oz by weight of the gas = 3¼ imperial gallons)

Reducing Valves—The gases under high pressure flow from the cylinders through a reducing valve which reduces the pressure to 5–7 lb/sq in Most reducing valves work on the principle of a spring-loaded diaphragm (which may be metal or rubber) controlling the size of an inlet opening and allowing the gases to escape through the outlet at a much reduced pressure The Adams valve shown in cross section is a typical example (*Fig* 40)

Minute Volumes and the Rebreathing Bag—Suppose the patient is breathing at a rate of 16/minute with a tidal volume of 500 ml, then the minute requirement for that patient = 16 × 500 = 8 litres Hence using an open or semi open circuit with no soda lime to absorb the patient's carbon dioxide at least 8 litres of gases must be supplied each minute to replace the air he normally breathes In anæsthesia this is usually supplied as 2 litres of oxygen and 6 litres of nitrous oxide Any lesser flow will result in carbon-dioxide accumulation and the consequent hyperpnœa described in the introduction

Although 8 litres/minute is the average minute volume, yet the 500 ml are inspired in 1/32 minute, a rate of 16 litres per minute for the period of inspiration Similarly, flow rates are higher in mid inspiration than at the beginning and end, i e the main bulk of the air passes in or out in the middle third of the cycle and at this time flow rates may be of the order of 24 litres per minute In order to obviate the need to supply this high rate of flow throughout the whole of the respiratory cycle, a reservoir or *rebreathing* bag is incorporated in the circuit A critical flow rate of 7–8 litres per minute from the machine will thus prevent rebreathing or carbon dioxide accumulation and the slack is taken up by the reservoir bag

Gas Flows—The gases flow from the reducing valves via the rubber tubing leads to the flowmeters and thence to the circuit of the machine During the passage of these gases through the tubing they obey the same laws as fluids flowing through tubes and the following basic physical principles should therefore be remembered —

3 *Stagnant hypoxia* Due to reduced blood-flow through the capillaries, e g, in shock, heart failure, or vasomotor collapse

4 *Histotoxic hypoxia* Rare—the tissues are unable to utilize oxygen, e g, cyanide poisoning

The anæsthetist's guide to the presence of hypoxia in this patient is *cyanosis* This occurs when there are 5 g of reduced hæmoglobin circulating in the minute vessels (or it may rarely be due to the presence of met- or sulph hæmoglobin)

The degree of cyanosis depends on —

1 The thickness of the epidermis

2 The pigmentation of the skin

3 The state of the cutaneous capillaries

The anæsthetist should always look on cyanosis as a warning that hypoxia is present, but should not forget that the anæmic patient may be grossly hypoxic without showing any cyanosis

Carbon Dioxide—Alveolar air contains 5–6 per cent of CO_2 Its elimination from the patient during anæsthesia is carried out by two main methods —

1 If using an open or semi open technique, the patient s minute volume requirements (7–8 litres) must be supplied to allow excess carbon dioxide to be eliminated via the expiratory valve

2 If closed or semi closed methods with small gas flows are used soda lime is incorporated in the circuit to absorb excess carbon dioxide

Effects of Carbon-dioxide Accumulation —

1 Hyperpnœa due to stimulation of the respiratory centre

2 Increase in heart-rate followed by a slowing due to a direct toxic action on the sino auricular node

3 Cutaneous vasodilatation Orton[3] has pointed out the dangers of carbon dioxide accumulation occurring in the curarized patient owing to hypoventilation Here the only danger signals may be an increase in pulse and increased vascularity in the operative field There is a rise in systolic blood-pressure

Reduced Carbon dioxide Level This condition is not infrequently produced using the various hyperventilation techniques

the flow rate Thus, though the viscosity of oxygen and helium is similar (20 19) their densities are as 32 4, and therefore nearly three times as much helium as oxygen will flow through an orifice in the same time

1 The flow rate through an orifice is proportional to the square root of the pressure difference between the two sides

2 With a given pressure difference, the flow rate of the gas is proportional to the square of the diameter of the orifice

Practical Applications —Flowmeters These make use of the relationship between flow rate, size of orifice, and pressure differences on either side of an orifice, to measure the rate of flow of gases passing through them Most modern machines work on the dry bobbin or rotameter flowmeter, in which the gases flow past the bobbin in a graduated conical tube The higher the rate of flow the higher the bobbin rises in the tube

OXYGEN AND CARBON DIOXIDE

Two cardinal principles which the anæsthetist should keep in mind when administering an anæsthetic are —

1 To supply sufficient oxygen for the body s needs

2 To ensure adequate elimination of the carbon dioxide

Oxygen —Except when administering a straight out gas and oxygen anæsthetic where some degree of hypoxia is perhaps permissible for a short time, the percentage of oxygen in the mixture should never fall below that in air, i e 20 per cent The likelihood of producing hypoxia by using small flows of gas and oxygen in a closed circuit is now fully realized Even with a semi closed circuit and flows of 2 litres of gas to 1 litre of oxygen the percentage of oxygen in the mixture may fall as low as 15 per cent as shown by oxygen-analyser samples

Hypoxia —May be of four types —

1 *Anoxic hypoxia* Due to a reduction in oxygen content or pressure in the inspired gases i e reduced ventilation, obstruction or reduced percentage of oxygen in the mixture, bronchospasm or pulmonary pathology

2 *Anæmic hypoxia* Due to reduced hæmoglobin content of oxygen or reduced amount of functioning hæmoglobin

3 *Stagnant hypoxia* Due to reduced blood-flow through the capillaries, e g , in shock, heart failure, or vasomotor collapse

4 *Histotoxic hypoxia* Rare—the tissues are unable to utilize oxygen, e g , cyanide poisoning

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Reduced Carbon dioxide Level This condition is not infrequently produced using the various hyperventilation techniques

Effects —

1 There may be a slight fall in blood pressure

2 Vasoconstriction of the skin vessels causing pallor

3 The *p*H of the blood is altered considerably, resulting in an alkalæmia

4 There is reduced cerebral blood flow due to constriction of the vessels This may account for the unconsciousness which can be produced by hyperventilation alone

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CHAPTER IV

AGENTS USED IN ANÆSTHESIA

ETHER

$((C_2H_5)_2O)$

Properties —

1 A colourless volatile liquid with a pungent smell

2 Molecular weight 74. Boiling-point 36 5° C

3 Specific gravity of vapour 2 6 (2½ times heavier than air)

4. Highly inflammable

5 Impurities may be acetic aldehyde or ether peroxide and can cause pulmonary œdema

6 Should be stored in a dark bottle in a cool place

Actions —Stimulates the sympathetic nervous system

Cardiovascular System —

1 Increases heart-rate at first [1]

2 Blood-pressure not much affected, but it causes a peripheral vasodilatation at light levels of anæsthesia.

3 Deep ether eventually causes a profound hypotension.

Respiratory System —

1 Stimulates respiration, then depresses it at deeper levels

2 Relaxes bronchial muscles

3 Irritant to the tracheobronchial tree, and increases secretions

Central Nervous System —

1 Excitement stage followed by anæsthesia

2 Dilates cerebral vessels and raises C S F pressure

Alimentary System —

1 May cause nausea and vomiting post-operatively

2 Mobilizes glycogen from the liver

Urinary System —Urinary secretion reduced

Miscellaneous —

1 Deep ether produces good relaxation of the uterus and is therefore useful for versions

2 It decreases body temperature and metabolism

Advantages and Disadvantages—

1 It is fairly non toxic and stops respiration well before affecting the heart

2 It causes good relaxation

3 It is a fairly safe agent even in inexperienced hands

4 It irritates the tracheobronchial tree

5 It is explosive and inflammable

Uses—

1 It is still the best general purpose anæsthetic drug in use, especially for children

2 Useful in asthmatics and emphysematous patients to relieve bronchospasm

METHYL N-PROPYL ETHER

(*Neothyl*—$CH_3\,CH\begin{matrix}CH_2\\CH_3\end{matrix}\!\!>\!O$)

Properties and Actions—

1 Green-coloured solution

2 Similar in action to ether but less irritant to the bronchial tree, causes less nausea and vomiting, is more potent, but said to have a wider safety margin

3 Has a peculiar smell, causing headache to many anæsthetists

4 Good analgesia, but not as good relaxation as with ether

DIVINYL ETHER

(*Vinesthene*—$(C_2H_3)_2O$)

Properties—

1 Clear fluid with a "fishy" smell

2 Very volatile and unstable

3 Explosive in air and oxygen

4 Stored in dark coloured bottles with 4 per cent ethyl alcohol and a trace of phenyl alpha naphthylamine to prevent breakdown

5 Prepared in 25-ml bottles and 5 ml and 3 ml ampoules

Actions—Rapid induction and recovery

Cardiovascular System—Thought to cause slight dilatation of the heart and cardiac irregularities have been recorded

Respiratory System.—Does not stimulate respiration, or dilate the bronchioles

Alimentary System.—Marked salivation at light planes of anæsthesia

Miscellaneous.—

1 Not recommended for long operations as liver necrosis has been recorded

2 Convulsions may occur during administration

Uses.—

1 For inductions
2 In children's dental operations

ETHYL CHLORIDE
(C_2H_5Cl)

Properties.—

1 Clear fluid with a sweet smell
2 Will burn in air
3 Hydrolysed by soda lime, therefore do not use in a closed circuit

Actions.—A potent drug with a small safety margin, the heart stopping shortly after respiration ceases

Cardiovascular System.—

1 Heart-rate decreased, then increased [2]
2 Causes a fall in blood pressure

Respiratory System.—

1 Respiration stimulated, then depressed
2 Comparatively non-irritant to the tracheobronchial tree

Alimentary System.—Liable to cause nausea and vomiting

Uses.—

1 Inductions before ether anæsthetics
2 Short operations

CHLOROFORM
($CHCl_3$)

Properties.—

1 Clear sweet-smelling liquid
2 Specific gravity 4 1 (vapour)
3 Non inflammable
4 The liquid is irritant to the skin

Actions —

1 Potent anæsthetic—2 per cent will cause respiratory arrest if prolonged

2 Very small safety margin between respiratory arrest and cardiac failure

Cardiovascular System —

1 Gradual fall in blood-pressure due to toxic effect on cardiovascular system

2 Cardiac arrest may occur owing to —

a Vagal inhibition

b Ventricular fibrillation

c Direct toxic effect on the heart muscle

This is more likely to occur when adrenaline is given at the same time *Never* inject adrenaline during a chloroform anæsthetic

Respiratory System —

1 Non-irritant to the respiratory system

2 Depresses respiration

Alimentary System —Nausea and vomiting in 40/50 per cent of post-operative cases

Urinary System —

1 Urinary secretion reduced

2 Post operative albuminuria may result

Miscellaneous —

1 May raise blood sugar 200–300 per cent, therefore not used in diabetics

2 Delayed chloroform poisoning may occur 1–3 days post-operatively, as a result of a toxic hepatitis

Uses —

1 Being non-volatile it is useful in the tropics

2 In domiciliary obstetrics to produce analgesia

TRICHLORETHYLENE

(*Trilene*—CCl_2 CHCl)

Properties —

1 Colourless liquid (usually coloured blue with 1–200 000 waxoline blue to distinguish it from ether and chloroform)

2 Specific gravity 1 47

3 Non explosive

4 Vapour five times heavier than air
5 Not very volatile
6 Decomposed by soda-lime to form dichloracetylene, resulting in cranial nerve palsies, therefore *never* use in a closed circuit

Actions —

Cardiovascular System —

1 Said to cause less oozing in the operative field
2 May cause cardiac arrhythmias, and is thought to sensitize the heart to the action of adrenaline [3]

Central Nervous System —Convulsions can occur rarely

Respiratory System —

1 Non-irritant to the respiratory tract
2 Tachypnœa occurs in 30–40 per cent of patients, resulting in shallow breathing and cyanosis
3 Sudden respiratory arrest can occur, especially in children if the concentration of the vapour is too strong

Miscellaneous —It is a good analgesic, fair narcotic, and a poor relaxant

Uses —

1 Analgesia in obstetrics
2 As an adjuvant to gas and oxygen
3 Useful where diathermy is being used for extra abdominal cases
4 Short out-patient operations

CYCLOPROPANE

(C_3H_6)

Properties —

1 Colourless gas with a sweet, musty smell
2 One and a-half times heavier than air
3 Liquefies at room temperature at 73 5 lb /sq in

Actions —4 per cent will cause analgesia 20–25 per cent moderate anæsthesia, 40 per cent respiratory failure [4]

Cardiovascular System —

1 At light levels the blood pressure rises and capillary oozing is increased
2 Cardiac arrhythmias are liable to occur If they do, reduce the concentration or change to some other agent

3 Sensitizes the myocardium to the action of adrenaline

Respiratory System —

1 Non irritant to the mucous membrane of tracheobronchial tree

2 Reflex laryngospasm may occur at high concentrations

3 Depresses respiratory centre

4 May cause bronchospasm

Alimentary System —Nausea and vomiting not marked post-operatively

Miscellaneous —

1 Not a good muscle relaxant, but its effect varies

2 Relaxes masseters and pharyngeal muscles, and thus facilitates intubation

3 *Causes priapism and therefore not suitable for operations* on the adult penis

4 Owing to its parasympathetic effect neostigmine should only be given after cyclopropane has been removed from the circuit

FLUOTHANE

(2 *bromo* 2 *chloro* 1 1 1 *trifluoro ethane*)

A new non explosive volatile anæsthetic agent •

Properties and Actions —

1 A clear, colourless heavy liquid, specific gravity 1 860 with a sweetish odour

2 Non inflammable and non explosive

3 Does not stimulate pharyngeal secretions and is non-irritant to tracheobronchial tree

4 Onset of anæsthesia is rapid and recovery is quick without nausea or vomiting

5 Causes a bradycardia and a fall in systolic pressure (reversed by atropine or the administration of ether)

6 Causes marked respiratory depression leading to cyanosis and carbon-dioxide retention

7 Cardiovascular collapse has occurred using *d* tubocurarine chloride and controlled respiration with fluothane

It is a comparatively untried agent, and though showing promise its use at present should be restricted to skilled anæsthetists

NITROUS OXIDE

(N_2O)

Properties —

1 A sweet smelling colourless gas

2 Non irritant, one and a-half times heavier than air

3 Non inflammable and non explosive

4 Non-toxic if given with adequate oxygen

Actions —

1 Its mode of action is not fully understood It dissolves in the blood plasma and exerts its effect by interfering with the metabolism of the cerebral cells That this effect is not purely asphyxial is shown by the fact that a true anæsthetic state is not obtained by the inhalation of an inert gas such as nitrogen Similarly anæsthesia can be produced by 80 per cent nitrous oxide and 20 per cent oxygen, the same oxygen percentage as in air

2 May produce nausea, vomiting, and headache post-operatively

OXYGEN

(O_2)

Prepared commercially by the fractional distillation of liquid air

Properties —

1 Specific gravity 1 005 in relation to air

2 Colourless and odourless gas

3 Under high pressure, may be explosive with oil or grease Hence, never oil the connexions from oxygen cylinders

4 Rapidly absorbed from the alveoli

Actions (100 *per cent oxygen*) —

1 May depress respiration at first by removing the stimulation via the chemoreceptors Later may stimulate it

2 May cause carbon dioxide retention by lessening the formation of reduced hæmoglobin, and therefore interfering with its excretion

3 Causes elimination of nitrogen from the body

4 Pulse rate is decreased (a chemoreceptor effect)

5 It causes a generalized vasoconstriction

CARBON DIOXIDE

(CO_2)

Properties—

1 Colourless and odourless gas

2 Non-inflammable

3 Rapidly absorbed from the alveoli

Actions—

Cardiovascular System—

1 At first it increases the heart-rate, but if over 6 per cent concentration, it slows the heart by a direct toxic action on the sino auricular node

2 It causes a peripheral cutaneous vasodilatation

Respiratory System—Stimulates the respiratory centre reflexly via carotid and aortic bodies and directly via the blood-stream It increases the depth first, then the rate of respiration

Central Nervous System—Over 6 per cent causes headache and mental confusion, progressing to unconsciousness and cessation of respiration It is a powerful agent in the anæsthetist s armamentarium and should be used with discretion

THIOPENTONE SODIUM

Properties—

1 Yellow amorphous powder with a sulphurous smell

2 Soluble in water or alcohol

3 Water-solution can be kept for 24–48 hours before use

4 Usually made up with distilled water to form a 5 per cent solution (½-g and 1 g ampoules)

5 Immiscible with *d*-tubocurarine chloride pethidine, and suxamethonium Miscible with gallamine triethiodide

Actions—

Cardiovascular System—

1 It causes dilatation of the heart and a weakening of its contraction

2 It lowers the blood pressure

Respiratory System—

1 Causes marked depression of the respiratory centre

2 Is liable to cause bronchospasm laryngospasm or coughing and sneezing

Central Nervous System —

1 Primarily a narcotic, with very little analgesic effect

2 Thought to act chiefly on the hypothalamus

Miscellaneous —

1 The plasma level of thiopentone soon falls, and the level in the fat depots rises

2 It may be detoxicated in muscular tissue, as well as in the liver

3 It readily crosses the placental barrier, and should be used cautiously in obstetrics

4 A localized muscular twitching may occur in the arm into which it is injected

THIALBARBITONE
(*Kemithal*)

Similar to thiopentone Used in a 10 per cent solution which must be used within six hours It is half as potent as thiopentone, and is thought to cause less respiratory depression and laryngospasm

BUTHALITONE SODIUM
(5 *allyl 5 isobutyl thiobarbituric acid*)

This is an intravenous anæsthetic with an ultra brief action[6] and short recovery period and is particularly useful for short procedures in the out-patient department Usually used as a 10 per cent solution Total dosage should not exceed ½–1 [illegible] or prolonged effects, 1 [illegible], dizziness, headaches, etc , occur It has very little analgesic effect and occasionally causes retching and/or hiccuping

PETHIDINE

Usually prepared in 50-mg and 100 mg ampoules which should be diluted with distilled water to 10 mg /ml for intravenous use

Actions —

Cardiovascular System —May cause hypotension and circulatory depression in a sensitive subject

Respiratory System —

1 It may cause depression of respiration so marked as to require assisted ventilation of the patient

CARBON DIOXIDE

(CO_2)

Properties—

1 Colourless and odourless gas

2 Non inflammable

3 Rapidly absorbed from the alveoli

Actions—

Cardiovascular System—

1 At first it increases the heart rate, but if over 6 per cent concentration, it slows the heart by a direct toxic action on the sino-auricular node

2 It causes a peripheral cutaneous vasodilatation

Respiratory System—Stimulates the respiratory centre reflexly via carotid and aortic bodies and directly via the blood-stream It increases the depth first, then the rate of respiration

Central Nervous System—Over 6 per cent causes headache and mental confusion progressing to unconsciousness and cessation of respiration It is a powerful agent in the anæsthetist's armamentarium, and should be used with discretion

THIOPENTONE SODIUM

Properties—

1 Yellow amorphous powder with a sulphurous smell

2 Soluble in water or alcohol

3 Water-solution can be kept for 24–48 hours before use

4 Usually made up with distilled water to form a 5 per cent solution (½-g and 1-g ampoules)

5 Immiscible with *d* tubocurarine chloride, pethidine and suxamethonium Miscible with gallamine triethiodide

Actions—

Cardiovascular System—

1 It causes dilatation of the heart and a weakening of its contraction

2 It lowers the blood pressure

Respiratory System—

1 Causes marked depression of the respiratory centre

2 Is liable to cause bronchospasm laryngospasm, or coughing and sneezing

Central Nervous System —

1 Primarily a narcotic, with very little analgesic effect

2 Thought to act chiefly on the hypothalamus

Miscellaneous —

1 The plasma level of thiopentone soon falls, and the level in the fat depots rises

2 It may be detoxicated in muscular tissue, as well as in the liver

3 It readily crosses the placental barrier, and should be used cautiously in obstetrics

4 A localized muscular twitching may occur in the arm into which it is injected

THIALBARBITONE
(*Kemithal*)

Similar to thiopentone Used in a 10 per cent solution which must be used within six hours It is half as potent as thiopentone, and is thought to cause less respiratory depression and laryngospasm

BUTHALITONE SODIUM
(5 *allyl-5 isobutyl thiobarbituric acid*)

This is an intravenous anæsthetic with an ultra-brief action[6] and short recovery period, and is particularly useful for short procedures in the out-patient department Usually used as a 10 per cent solution Total dosage should not exceed ½–1 g or prolonged effects, i e, dizziness, headaches, etc, occur It has very little analgesic effect and occasionally causes retching and/or hiccuping

PETHIDINE

Usually prepared in 50-mg and 100 mg ampoules which should be diluted with distilled water to 10 mg/ml for intravenous use

Actions —

Cardiovascular System —May cause hypotension and circulatory depression in a sensitive subject

Respiratory System —

1 It may cause depression of respiration so marked as to require assisted ventilation of the patient

2 It dilates the bronchi and depresses laryngeal reflexes

3 Reduces the tachypnœa produced by trilene

(*N B* —The secret of using pethidine is to dilute it and give it slowly in small doses (25–50 mg) I have not yet seen a reaction where this technique has been followed)

Alimentary System —

1 Contracts the sphincter of Oddi, and hence may interfere with an exploration of the common duct

2 Causes very little nausea and vomiting post-operatively

Central Nervous System —

1 An excellent analgesic and lessens the need for post-operative sedation

2 May cause a 'flare' reaction if given into a superficial vein

RELAXANTS

(*Competition Inhibitors*)

D-TUBOCURARINE CHLORIDE

(*Tubarine*)

Properties and Actions —

1 A colourless fluid usually made up in 15-mg ampoules (10 mg /ml) or 50 mg rubber-capped bottles

2 Is neither anæsthetic nor analgesic

3 Produces muscular relaxation by interfering with the action of acetylcholine at neuromuscular junctions (competitive inhibition) [7]

4 Takes 2–3 minutes for the full effect, and lasts 30–40 minutes

5 Ordinary tubarine is immiscible with thiopentone and pethidine (*N B* —A miscible form is produced which is more expensive)

6 Has a lesser effect on the synapses of sympathetic ganglia

Cardiovascular System —

1 Capillary oozing is increased

2 No demonstrable effect on heart or blood pressure using clinical doses

Respiratory System —

1 Depresses respiratory and laryngeal and bronchial reflexes

2 May occasionally cause bronchospasm

Miscellaneous —

1 Slow to cross the placental barrier, so can be used for Cæsarean sections

2 Detoxicated by the liver and excreted by the kidneys

GALLAMINE TRIETHIODIDE
(*Flaxedil*)

Properties and Actions —

1 Colourless 4 per cent solution made up in 2-ml and 3-ml ampoules (80 mg and 120 mg) (*N B* —15 mg of tubarine = 80–100 mg of flaxedil)

2 Miscible with thiopentone and pethidine

3 Its effects are similar to tubarine except that —

a Its effect is maximal in ½–1 minute and lasts 20–30 minutes

b It has less histamine-release effect and is therefore better for asthmatics and bronchitics

c It produces a marked tachycardia due to a vagal blocking effect Hence it is perhaps wiser to use tubarine in heart cases prolonged operations, and in shock

4 It is excreted by the kidneys and care is needed in renal impairment

LAUDEXIUM METHYLSULPHATE
(*Laudolissin*)

Properties and Actions —

1 It is half as strong as *d*-tubocurarine chloride

2 Its maximum effect takes 4–5 minutes and lasts 30–45 minutes

3 It is a poor intubating agent

4 It is not miscible with thiopentone or pethidine

DEPOLARIZERS
SUXAMETHONIUM HALIDES

1 *Suxamethonium Chloride* (*Scoline*) —A colourless 5 per cent solution made up in 2-ml ampoules of 100 mg (80 mg of active cation)

2 *Suxamethonium Bromide* (*Brevidil M*) —Produced in ampoules containing 60 mg of dry powder (40 mg of active cation)

3 *Suxethonium Bromide (Brevidil E)*.—Made up in ampoules containing 150 mg. of dry powder.

Properties and Actions.—

1 Short acting relaxants causing depolarization of the motor end-plates.

2 Maximal effect in 30 seconds, lasting 2–6 minutes. Depolarization is preceded by stimulation, causing muscular twitchings, which are painful for the conscious patient.

3 Cause profound relaxation of vocal cords and voluntary muscles.

4 Prolonged apnœa may result in some cases possibly due to the patient's low pseudo-cholinesterase level, e.g., in starvation, debility, etc.[8]

5 Cause an initial rise in blood-pressure on injection.

6 Have a synergistic action with neostigmine, causing prolonged apnœa.

Hence *never* give neostigmine to reverse the effect of these drugs.

ANALEPTICS

N-ALLYL NORMORPHINE

(*Lethidrone*; *Nalline*)

Properties and Actions.—

1 Closely related to morphine and acts as an antidote.[9]

2 Reverses the respiratory depression and narcosis, but not the analgesia, produced by morphine and pethidine, etc.

3 Does not reverse the effects of barbiturates.

4 Small doses 5–10 mg. intravenously are effective; larger doses may give morphine-like effects.

CORAMINE

(*Nikethamide*)

Properties and Actions.—

1 Stimulates the carotid and aortic bodies and the respiratory centre.

2 Acts as a convulsant if an overdose is given.

3 Reverses the effect of barbiturates and other sedatives.

4 Dose 2–5 ml. intravenously.

VASOPRESSORS

METHYLAMPHETAMINE HYDROCHLORIDE

(*Methedrine*)

Properties and Actions —

1 Probably the best of the longer acting drugs for raising blood-pressure, as it does not constrict the renal vessels

2 Dose 15–20 mg subcutaneously or 10–15 mg intravenously and 10–15 mg subcutaneously

3 Increases heart-rate, and force of contraction

4 Produces vasoconstriction by a direct action on the vessels

5 Effect is maximal in 6–8 minutes and lasts 25–30 minutes

L-NORADRENALINE

(*Levophed*)

Properties and Actions —

Cardiovascular System —

1 The best vasoconstrictor, acting on all vessels except gut and heart [10]

2 Reduces renal flow

3 Used as a drip to combat hypotension, 2–4 ml of 1–1000 solution added to 500 ml of saline, and the speed of the drip regulated by the blood-pressure reading Care must be taken to stop the drip gradually or the blood pressure may fall again It is sometimes necessary to wean the patient to a longer acting drug, such as methedrine

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CHAPTER V

PRE-OPERATIVE CONDITIONS REQUIRING SPECIAL CARE IN ANÆSTHESIA

I CARDIOVASCULAR CONDITIONS

WHERE the patient is suffering from some pre existing cardiovascular disease, two things must be avoided —

1 Hypoxia

2 A sudden fall in blood pressure The quality of the anæsthetic counts for much more than the agents used It is essential to have an incident-free induction, with no episodes of laryngospasm etc, and a smooth maintenance

1 Congestive Heart Failure —

a Uncompensated —These are poor risk cases Where the operation can be postponed, it is wiser to treat the cardiac condition first by digitalis diuretics, etc Where the operation is urgent 0 25–0 5 mg of digoxin can be given intravenously and the anæsthetic proceeded with

b Compensated —These cases carry a slightly greater risk than normal, but take general anæsthesia fairly well if hypoxic episodes are avoided

2 Hypertension —Here again there is a slightly greater risk but with care in induction and maintenance they should not cause worry

3 Hypotension —If due to shock it is a good working rule not to give a general anæsthetic until the blood pressure has been raised to 100 mm Hg systolic, for at least half an hour Similarly patients with a blood pressure of under 100 mm Hg tolerate spinal analgesia poorly

4 Coronary Occlusion —

a Recent —Patients who have suffered from coronary occlusion should if possible avoid operation for 3–4 months Even local or regional analgesia may initiate a further attack

b Old—Patients with a history of coronary occlusion occurring at least 9–12 months previously do fairly well if hypoxia and hypotension are avoided, i e, if the coronary circulation is not upset

5 **Acute Rheumatic Carditis**—Is a contra indication to all but the most urgent operations

6 **Auricular Fibrillation**—If the fibrillation is at a rate of over 100 per minute, the patient should if possible be digitalized before operation In emergencies 0 25–0 5 mg of digoxin can be given intravenously Cyclopropane should probably be avoided in these cases

7 **Angina Pectoris**—Treat as for coronary occlusion

In all these types of patients, it is their functional capacity rather than the organic lesion which concerns the anæsthetist If they can get through an ordinary day s work or potter round at home without becoming too distressed, then no matter what their lesion is, they will tolerate a general anæsthetic fairly well Let me stress again, in these cases it is the *quality* of the anæsthetic, rather than the agents used, which is the important factor

A useful test of cardio-respiratory reserve is the breath-holding test of Sebrasez The patient takes a full breath and holds it as long as he can Anything under 15 seconds indicates poor reserve (normal 25 seconds)

II RESPIRATORY CONDITIONS

1 **Coryza**—Whether to operate or not in the presence of the common cold is a question frequently put to the anæsthetist and it is often a vexed one The following principles may act as a guide when confronted with this problem —

a So far as we know coryza is a virus infection affecting the upper air passages, but not the tracheobronchial tree

b If the operation is urgent, some form of anæsthesia can be found to minimize the risk of post-operative pulmonary complications

c Non urgent abdominal cases herniorrhaphies, and E N T cases are probably better postponed

d In other cases it is better to decide whether the disadvantages of postponement outweigh those of proceeding

For example, the postponement may cause pronounced depression in the patient whose doctor has gone to considerable trouble to arrange his admission. The risk of the extension of a secondary infection can be minimized by —

i Using a non irritant anæsthetic such as cyclopropane or trilene and avoiding the use of ether

ii The use of the appropriate antibiotic

iii Post-operative physiotherapy to prevent atelectases, etc

To sum up, as Ellis[1] so aptly puts it, "although anæsthesia may not be good treatment for the common cold, might it not be a good way of passing the time till the cold is gone?"

2 **Asthma**—Asthmatics are liable to turn on an acute attack during an anæsthetic. The following measures can minimize or alleviate the condition —

1 *Include an antihistamine with the premedication, e g*, promethazine hydrochloride or mepyramine maleate

2 Parry-Brown states that the injection of 1 ml of 10 per cent cocaine into the trachea via the cricothyroid membrane before induction will avoid an attack

3 Thiopentone often initiates an attack and it should be given slowly and in small doses

4 Avoid cyclopropane and trilene, and incorporate some ether in the mixture to act as a bronchodilator

5 0 25 mg of aminophyllin intravenously or 4–8 minims of 1–1000 adrenaline subcutaneously will relieve an attack

3 **Acute Bronchitis, Bronchopneumonia, Lobar Pneumonia**—Avoid anæsthesia in the acute stage unless absolutely necessary

4 **Chronic Bronchitis Bronchiectasis**—Where the operation is non urgent the patient should be made as dry as possible pre-operatively by a course of 10–14 days of antibiotics postural drainage and inhalations of 1 per cent isoprenaline (1 ml b d)

In urgent cases it may be necessary to bronchoscope the patient after induction and employ intermittent suction via the endotracheal tube during anæsthesia. These can be very trying cases for the anæsthetist, and the use of local analgesia may often solve the problem

III METABOLIC CONDITIONS

1 **Thyrotoxicosis** —Very few really toxic patients come to operation nowadays They are usually prepared by a course of thiouracil or Lugol s solution to reduce the B M R to near normal levels The occasional case is still seen when an untreated thyrotoxic patient is admitted for an urgent operation e g, ruptured appendix etc The septic focus would appear to exacerbate the thyrotoxicosis and these patients require careful premedication and induction (preferably before going to the theatre) if a crisis is to be averted The oxygen consumption of a thyrotoxic is high and an oxygen rich mixture should be used

Post operatively, these patients require careful watching for the first signs of a crisis i e, rising pulse rate restlessness etc The treatment is by giving Lugol s solution intravenously (100 minims given slowly in a glucose saline solution) and the administration of oxygen

2 **Diabetes**[2, 3]—The controlled diabetic can be treated as a normal patient avoiding the use of chloroform ether, and bromethol which are glycogenolytic

a The Diabetic controlled by Diet —These patients should be given an extra 50 g of glucose plus 10 units of insulin the day before and the day after operation

b The Diabetic on Insulin —A good working rule is Replace the long acting insulin with soluble for the preceding 24 hours Substitute 50 g of glucose plus 25 units of insulin (+ 10 units if ether is used) for the last meal (*N B* —This must be given at least four hours pre-operatively, as the glucose being hypertonic remains longer in the stomach and may be aspirated during induction The glucose may be given intravenously (one pint of 5 per cent glucose = 25 g))

The patient goes on to four-hourly urine tests for 24 hours post-operatively and soluble insulin is given according to the result of the tests He returns to the longer acting insulin on the following day

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CHAPTER VI

INTUBATION

INTUBATION of the trachea has become such a routine procedure that anæsthetists have rather tended to use it indiscriminately, without questioning whether its use is justified or not It is sometimes salutary to sit back and consider whether its use was for the benefit of the patient or if it was really to save the anæsthetist the tedium of jaw holding

Even in the best hands there is an increased rate of morbidity and even mortality associated with the use of endotracheal tubes and there should always be a clear indication for their use Apart from minor trauma inflicted on teeth and gums by the beginner, and the increased incidence of pharyngitis and tracheitis actual granulomata of the cords may result There have been 23 recorded cases to date and there must be a large percentage of missed cases owing to the fact that they do not cause symptoms until several weeks after the patient has been discharged

Many writers have recorded marked E C G changes during intubation These showed reflex effects on the heart, including vagal inhibition prolongation of the P R interval ventricular extrasystoles, and bradycardias These effects were more marked when there was difficulty in intubation with associated laryngospasm and hypoxia

These changes may be of minor importance in the fit subject but they are a very real factor in the poor-risk patient where the smallest fault in technique may spell the difference between success and disaster

Dwyer and others[1] and Kamsler[2] report two cases of cardiac arrest, one of which was fatal occurring at the moment of intubation

Keeping these facts in mind we can realize the importance of small points in technique, which we tend to omit, if the surgeon is in a hurry —

The importance of —

1 Fully oxygenating the patient before attempting intubation

2 Waiting the 1–2 minutes required for the relaxant to act

3 Additional spraying of cords and trachea with a local analgesic especially in poor-risk cases

The glottic reflex is a deep rooted protective mechanism, and when we abolish it by means of any of our modern drugs, we should remember that we are legally and morally responsible for anything which may occur to the patient during the period that this protective reflex is in abeyance I am sure the increased incidence of post operative bronchitis and minor 'chests' which occurs with the use of relaxants is due to the neglect to suck out secretions from the pharynx post-operatively They are allowed to trickle down into trachea and bronchi before the laryngeal reflexes become fully active

INDICATIONS FOR INTUBATION

1 Abdominal operations, where relaxants are used, to allow of assisted or controlled respiration

2 Neurosurgical E N T operations, and operations on the head and neck

3 Prolonged operations on other parts of the body, e g, plastic operations where endotracheal anæsthesia enables the patient to be run at a lighter level and the patient therefore needs less anæsthetic

4 Thoracic and cardiac operations

5 Operations in difficult positions, e g, prone

6 Various emergency operations, to prevent aspiration of stomach contents

METHODS OF INTUBATION[3]

1 **The Use of Relaxants** —Where relaxation of muscles is required in addition to laryngeal relaxation e g, abdominal and thoracic cases this is the method of choice There is no doubt that relaxants obtund the laryngeal reflexes, but whether they prevent vagal effects on the heart is open to doubt

2 **Cricothyroid Puncture**—Intubation can be carried out by introducing local analgesic (2 ml of 4 per cent lignocaine or 1–1½ ml of 5 per cent cocaine), with a syringe and needle, into the trachea, via the cricothyroid membrane. This causes the patient to cough, and spray the solution up over the cords thus paralysing them.

Contra-indications—

a The nervous patient.

b Bull necked patients where the landmarks are not easily palpable.

c Intra-tracheal infection, which may track along the needle hole.

The technique must be carried out on the conscious patient as, if thiopentone is given first the patient is either too deep and fails to cough or too light and jerks his neck away when the puncture is attempted. A 16 gauge needle is used, as smaller ones may break off and disappear into the trachea. The puncture is made, and air aspirated, to be sure the point is in the trachea before the solution is injected.

It is not a procedure readily tolerated by the patient but its use is justified for bronchoscopies, thoracic and cardiac operations etc., where a thorough topical application of the tracheobronchial tree is required.

3 **Suxamethonium and Lignocaine Spray**—Where it is desired to intubate the patient yet have him breathing on his own, e.g. head and neck operations the following method is satisfactory:—

The patient is induced with thiopentone and 50–75 mg of suxamethonium is given. After inflation with oxygen the whole trachea as far down as the carina and also the cords are sprayed with a Macintosh type of syringe. The endotracheal tube is introduced and as the effect of the suxamethonium wears off the patient commences to breathe on his own without any gagging or objection to the tube. If the spraying is omitted, much more relaxant or general anæsthetic is required to settle the patient.

The only contra-indication to this method is perhaps in cases of intracranial hæmorrhage where the transient rise in

blood pressure, which accompanies the administration of suxamethonium, may start fresh bleeding

How to Pass the Tube —

Orotracheal Intubation —This is the method of choice in most cases because —

1 A tube of larger bore can be introduced

2 No damage is caused to the turbinates, as occurs frequently with the nasal route

3 There is no danger of introducing infection or blood from nasal fossæ into the trachea

Technique, using a Macintosh laryngoscope (*Figs* 41, 42) —

1 Withdraw the pillow from beneath the patient's shoulders, and place it under his head

2 Flex the neck and extend the occiput

3 Open the patient s jaw, using thumb and index finger of right hand

4 Grasp the laryngoscope in the left hand and slide the blade gently down the back of the tongue until the tip sits in the glosso epiglottic fold (*N B* —Take care that the under lip is not rolled over the teeth with this manœuvre)

5 Now firmly lift the laryngoscope upwards and towards the patient's feet The epiglottis can now be seen as it is lifted forwards with the base of the tongue

6 If the blade is now angled slightly forwards, the cords and trachea come into view and the endotracheal tube is passed, using the right hand (*N B* —If the laryngoscope is angled too much, the central upper incisors may be chipped The essential manœuvre is a lift up and away from the anæsthetist)

7 In difficult cases a better view is obtained if an assistant pulls the upper lip back with his finger

Technique, using a Magill blade The technique is similar, but the straight blade is passed down the posterior pharyngeal wall and lifts the epiglottis with its tip It is easier to use with a long prognathus jaw,[4] but more difficult if the patient has all his own teeth

Nasotracheal Intubation —This method is used in tonsillectomies, and other oral operations

Technique. A well-lubricated, uncuffed tube (size 5–7 for adults) is passed down the nostril which appears to have the clearest airway, until the tip lies in the posterior pharynx.

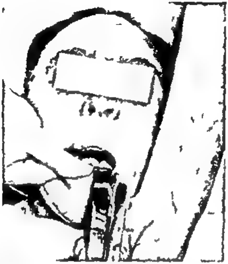

Fig. 41.—Technique of introducing the Macintosh blade by sliding it down the dorsum of the tongue. Note the laryngoscope is held in the left hand while the mouth is opened using the right index and thumb.

Fig. 42.—The endotracheal tube about to be introduced. Note the flexion of the neck, extension of the head and the upwards and forwards lift to the handle of the laryngoscope.

A Macintosh laryngoscope is inserted as already described and the tip of the tube grasped in Magill forceps and gently placed between the cords. A push on the proximal end places

it in the trachea This method is preferable for the anæsthetist who is not expert at blind methods, as less trauma is inflicted

Blind Nasal Intubation —The anæsthetist should be able to pass an endotracheal tube by this means, as cases arise in which it remains the only practical method of intubating the trachea, e g , trismus from dental abscesses, Ludwig's angina, etc (For technique, *see under* EMERGENCY ANÆSTHESIA)

The Endotracheal Tubes —Not infrequently the tubes used are too long for the patient If this mistake is made, they will either impinge on the carina, and initiate bronchospasm, or enter the right bronchus, with resultant one-lung anæsthesia This is particularly liable to happen with children, and care should be taken to see that both sides of the chest move evenly after intubation Cuffed tubes, though of great value, have their dangers A fatal case is recorded where over-inflation of the cuff occluded the distal end of the tube On another occasion, the tracheal mucosa sloughed, after a prolonged thoracic case, because the cuff had been too firmly inflated [5]

The anæsthetist should not relax his vigilance concerning the patient's airway after intubation The patient can still become obstructed by kinking of the tube, either at the level of the teeth, or lower down in the pharynx Another cause of obstruction can be a plug of mucus obstructing the lumen of the tube

Extubation —The anæsthetist's worries are not over when he has successfully intubated the patient Laryngeal spasm can occur at the end of an operation, on the removal of the tube, particularly if the patient is too light

Shumacker and Hampton report five cases of cardiac arrest (admittedly in poor-risk patients) following extubation

The solution is either to keep the patient on a slightly deeper plane of anæsthesia, or, better, to apply a topical spray to cords and trachea

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CHAPTER VII

PREMEDICATION AND BASAL NARCOSIS

INTELLIGENT premedication of the patient is an important part of the anæsthetist's duties. The dosage should not be standardized but should be worked out after seeing the patient, and taking into account the various factors involved. The weight, size, and general physique of the patient should be allowed for when estimating the required dosage, and also the type of operation to be performed.

Thin nervous wiry patients usually require as much premedication as their somewhat heavier but phlegmatic brethren. Children over one year should preferably be asleep when they arrive in the anæsthetic room. The day of clamping a mask over a screaming infant's face is, we hope, gone for good.

The elderly, the toxic, the debilitated, those with intestinal obstruction or those suffering from shock, do not require a great deal of sedation.

Reasons for Premedication.—

1 *Sedation.—Omnopon, Morphine, Pethidine, Dromoran.*

a To produce a subjective psychic effect on the patient, removing the affect and to induce a state of well-being.

b To produce narcosis and a reduction in metabolism.

c To reduce the amount of general anæsthetic used.

2 *Paralysis of Autonomic Effects.—Atropine and Hyoscine.*

a To reduce secretions, i.e., mucus which might initiate laryngospasm.

b To prevent the inhalation of saliva.

c Possibly to stop vagal cardiac effects, e.g., arrhythmias.

3 *To prevent Toxic Effects from Injections of Local Solutions.*— Barbiturates are frequently given as premedication for this reason.

4 *To maintain Blood pressure.*—Methedrine is often given before a spinal analgesic to prevent a fall in blood pressure.

5 *Other Effects*.—Antihistamines, antispasmodics, etc., are often given as premedication in special cases.

Side-effects.—

1 Nausea and vomiting—morphine is a frequent offender in this respect.

2 Constipation.

3 Respiratory depression leading to cyanosis.

4 Itchiness of skin.

Premedication for Age.—It is quite a good idea to have a premedication chart in each ward for the use of the surgical house surgeons. It should be emphasized that it is meant as a guide only, and should be used intelligently, with due regard for the individual preferences of the surgeon or anæsthetist concerned, and the size and robustness of the patient.

PREMEDICATION CHART[1]

0–1 year. Atropine gr. 1/150 half an hour pre-operatively.

1–8 years. Pentobarbital sodium *or* butobarbitone { gr. 0.6 per stone. 1¼ hr. pre-operatively. (Max. dose gr. 3.)

+ Atropine gr. 1/100 half an hour pre-operatively.

or Rectal thiopentone 1 g. per 50 lb. weight half an hour pre-operatively. (Max. dose 1½ g.)

+ Atropine gr. 1/100 as soon as the child has fallen asleep.

N.B.—Nepenthe 1 minim per year of age + 1, given post-operatively as soon as the child is awake, will prevent the restlessness due to pain. The rectal thiopentone is a 5 per cent solution which can be made up with tap water. It is given via a lubricated catheter which is clamped and left in position until the child is asleep. The buttocks are strapped together with plaster. The oral barbiturates should be removed from their capsules and the powder given in honey or jam to ensure that the child really swallows it.

8–16 years	Morphine gr. 1/40 per stone + Atropine gr. 1/100	¾–1 hour pre-operatively
16–60 years	Omnopon gr. 1/6–1/3 + Scopolamine gr. 1/150	1–1½ hours pre-operatively

60–70 years	Pethidine 50 mg + Atropine gr 1/100	1 hour pre-operatively
Over 70 years	Atropine gr 1/100	½ hour pre operatively

The reason for the change to pethidine after 60–65 years is that the omnopon-scopolamine mixture depresses respiration markedly in the elderly Also the occasional case of scopolamine mania occurs

Emergencies —

Children Atropine gr 1/150–1/100 half an hour pre-operatively

Adults	Pethidine 50–100 mg + Atropine gr 1/100	three-quarters of an hour pre-operatively
or	Atropine gr 1/100	half an hour pre operatively

(*N B* —Either can be given intravenously for quicker effect)

Suiting the dose and type of premedication to the patient and the operation to be performed can make all the difference to the induction and maintenance of the anæsthetic A nervous and apprehensive patient requires considerably more general anæsthetic, and is more likely to suffer post anæsthetic sequelæ A little time spent on working out the correct dosage and timing for the premedication is amply repaid

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CHAPTER VIII

GENERAL ANÆSTHETIC TECHNIQUES

ETHER*

ETHER is a colourless volatile liquid with a pungent smell The vapour is inflammable when mixed with air, explosive when mixed with oxygen, and heavier than air It is readily vaporized by dropping the liquid on to a piece of towelling spread over a wire-frame mask through which the patient breathes

Ether is the safest anæsthetic of all because the stages of anæsthesia are passed through slowly, and there is a margin between respiratory and cardiac arrest On this account it is also the ideal agent for teaching purposes

If a patient breathes about 20 per cent of ether vapour in air he will in time, become anæsthetized Difficulties are —

1 Ether irritates the mucosa of the respiratory tract, causing breath-holding and a feeling of suffocation therefore the concentration should be very low at first and increased so gradually that it will hardly be noticed by the conscious patient This also applies when the patient is unconscious

2 A 20 per cent mixture of ether in air is obtained only with difficulty under the anæsthetic mask Only 14 per cent can be obtained under a single layer of towelling so 'muffling-up' is carried out to obtain 20 per cent Muffling-up means covering the mask with several layers of towelling and gamgee tissue leaving only a small area of single layer of towel on to which ether is dropped With other more potent anæsthetics and when 14 per cent of ether is adequate, e g, in babies this muffling up is unnecessary and may be dangerous

This long period of slowly increasing the concentration until the patient is anæsthetized is unpleasant to the patient To

* From Anæsthetic Notes for Medical Students University of Otago Medical School

avoid this it is usual to give a more potent anæsthetic, and one which is more pleasant, until the patient is unconscious, and then to change over to ether. Ethyl chloride is the agent most commonly used for induction.

Ethyl Chloride is a potent anæsthetic, and is therefore more dangerous than ether. A concentration of 3–4 per cent will anæsthetize the patient, therefore it can be given slowly on an open mask with plenty of air.

Remember that whatever concentration is given time has to elapse for the vapour to get to the alveoli, and build up a high enough concentration in the blood-stream to anæsthetize the patient.

Ethyl chloride should be given *only until the patient loses consciousness*, shown by cessation of crying, talking, or counting. At this stage, when the concentration in the alveoli is high enough to produce unconsciousness, the concentration under the mask will usually be higher, and during the next 30 seconds the patient will go deeper, even though no more has been placed on the mask. So avoid giving that extra bit of ethyl chloride for luck when the patient stops counting, and do not have too much on the mask when you change over to ether.

The change over to ether should be made rapidly, so that the effect of the ethyl chloride does not have time to wear off. If this is done rapidly enough, it will be found that the patient will tolerate the highest concentration of ether that can be given on an open mask—i.e. 14 per cent. This concentration will be obtained if the mask is damp without being really wet. If too dry, the concentration will be too low; if too wet, the air to vaporize the ether will be drawn through the towel with difficulty.

Ethyl Chloride-Ether Sequence.—*Routine.* Satisfy yourself that you have the correct patient and see that the ordered premedication was given at the right time. Say a few words to the patient to reassure him, ask him about his nasal airway, and check to see that all dental plates have been removed. (It is presumed that the patient has previously been checked over by some reliable person, preferably the anæsthetist himself, to see that he is fit for anæsthesia.)

Then commence the anæsthetic.

Close the patient's eyes—gamgee with opening over nose and mouth

Mask—single layer of towelling—preferably resting on patient's chin only, with upper edge held off face

Ask patient to count out loud slowly after you, then begin to drop ethyl chloride on to mask very slowly especially for his first few breaths If patient falters in his counting, jog him on

It may be preferable for the patient to count by himself after perhaps twelve breaths, his regular breathing is less likely to be upset if the anæsthetist does not continue to count regularly

When counting stops, *repeat the next number or so*, and if no response, change over—pour on ether rapidly until mask is well damped, and slip a hand under the chin to prevent it dropping

Keep mask damp

After the remains of ethyl chloride have vaporized (½ minute) muffle up, so that small single layer opening is in the centre, and several layers elsewhere Any breathing should be very obvious at this opening

If for an abdominal operation keep mask well damped until the surgeon isolates what he is after, and finds the patient relaxed enough

Do not waste time looking at the eyes if the patient is obviously not deep enough, except possibly to see if movements have ceased—i e at the end of the first plane

Much more important than the eye signs are the observations on the breathing—its type regularity and whether intercostal or diaphragmatic

The airway at all times is most important because —

a If the patient breathes freely he will get plenty of ether and will go under more quickly A poor airway means less ether going into the patient, and less relaxation for the same depth of anæsthesia

b If a patient is going to die during ether anæsthesia, it will be from anoxia due to obstructed or depressed respiration Therefore it cannot be stressed too much that unobstructed respiration, and an adequate respiratory exchange are the most important factors in anæsthesia

Oxygen may be run under the mask by means of a catheter if desired, but remember it is more important to correct a need for extra oxygen, i.e., inadequate respiratory movement or partial obstruction to respiration.

Oxygen will only correct a lack of oxygen and not the other ill effects of inadequate respiratory exchange, and may give a sense of false security.

If these points are appreciated, it may be a wise precaution to give extra oxygen (2 litres per minute or more) as a routine to all young children because of their high metabolic rate, and to minimize the increased dead space caused by the mask.

Thiopentone-Ethyl Chloride-Ether.—A minor variation on the ethyl chloride–ether sequence, which avoids the disordered sensations experienced as consciousness is slowly lost, is to produce very temporary unconsciousness with a small dose of intravenous thiopentone before administering the ethyl chloride.

The only difference in the technique after the thiopentone has been given and the respirations have returned, is knowing when to stop giving ethyl chloride since the patient is already unconscious.

It should be realized that there is not only a danger from too much ethyl chloride—cessation of respiration, severe fall in blood-pressure—but also from too little ethyl chloride.

Thiopentone makes the normal protective reflex of the glottis extremely sensitive, and an irritant vapour, such as ether, may cause the glottis to close and remain closed for an appreciable time as laryngeal spasm.

Ethyl chloride and nitrous oxide appears to reduce the sensitivity to normal levels if a dose of 10–12 ml. is given to the *average patient*. This same amount, if used by itself, would be just enough to produce unconsciousness.

Although a dose system of ethyl chloride may not be very accurate, it avoids the extremes of a dangerous amount and a dose which is quite inadequate, to obtain the desired effect.

Note that unless ethyl chloride is dropped on to the mask *very slowly*, the patient will not have had an opportunity to get the full benefit of the limited dose before the change over to ether is made.

The method we use is to give 0·15–0·25 g of thiopentone (i e, 3–5 ml of the usual 5 per cent solution) depending on the size and 'toughness' of the patient This dose is given rapidly, and when the resulting apnœa has passed off and the patient is breathing adequately, the *slow* dropping on of ethyl chloride begins, 8–12 ml of this is given, depending again on size and robustness of patient

The change over to ether is exactly the same as before, and provided you have not underdosed the patient with ethyl chloride, there should be no difference in his reaction to your vigorous pouring on of ether

DIFFICULTIES ENCOUNTERED DURING ETHER ANÆSTHESIA

1 **Obstruction to the Airway**—Signs of obstruction are —

Straining on inspiration
Diminution or absence of respiration
Snoring or crowing noise
Possible cyanosis and signs of anoxia

The most common causes are —

a Tongue falling back—This is corrected by pulling the jaw forward In many cases this is sufficient, but if the obstruction persists insert an artificial airway Frequently a patient becomes obstructed during the early stages of anæsthesia and it becomes impossible to push the anæsthetic deeper Under such conditions the jaw is often in tight spasm, but a nasopharyngeal tube overcomes these difficulties, and provides at least a sufficiently good airway to push the anæsthetic deeper If necessary, an oropharyngeal airway may be inserted later, when the jaw is sufficiently relaxed You should practically never have to force open a jaw to insert an airway

It is a good rule to insert an airway in all cases where the peritoneum is opened even though the air-passage may appear satisfactory because a good airway provides added relaxation for the same depth of anæsthesia

b Laryngeal Spasm is the second most common cause of obstruction It is most liable to occur during induction and may be partial or complete Diagnosis is made from signs of

respiratory obstruction and if not complete, a characteristic high pitched crowing noise from the larynx The spasm may be —

Direct Irritation from sudden increase in the ether vapour, blood, mucus, vomit, or foreign bodies

Treatment is by removal of the irritating agent, assurance of a good airway, and an adequate supply of oxygen

Reflex This occurs not infrequently when the patient is anæsthetized too lightly for the surgeon's manipulations This is particularly liable to occur in intra abdominal surgery, and often a vicious cycle is set up The only way to overcome this is by pushing the patient deeper Often this is extremely difficult owing to the impaired respiratory exchange It may be necessary to ask the surgeon to stop until the spasm is abolished and the patient can be pushed deeper Occasionally it is necessary to intubate to abolish spasm

c Obstruction due to the Patient's Disease—Poor nasal airway e g polypi especially if patient is edentulous and lips are held too tightly together enlarged thyroid, tumours, etc

d Obstruction due to Foreign Bodies—Mucus blood, vomit foreign bodies

2 **Respiratory Depression and Arrest**—Respirations become shallow and rapid at two stages —

a When the patient is very deep, and nearing respiratory arrest

b When the patient is very light and often just before he vomits

In this case you have to decide quickly which stage the patient is in The amount of ether you have used the presence or absence of intercostal breathing and a quick look at the eyes to see whether they are roving should decide this

Arrest—The commonest cause of momentary cessation of respiration is light anæsthesia The most important cause of cessation of respiration is depth of anæsthesia If in doubt treat as deep

If arrest is due to depth stop the anæsthetic See that the patient has a good airway and keep an eye on his colour Almost always respiration will commence spontaneously, but occasionally it is necessary to perform artificial respiration if

his colour is poor, by a few sudden 'pushes' on his sternum, and give extra oxygen

3 **Vomiting**—This is most liable to occur during induction It may occur in any patient, but more frequently in the unprepared patient

No person should have an anæsthetic until at least 4 hours after a meal Children are likely to vomit solid food for 8–12 hours after a meal This applies to acute urgent cases and should be regarded as the minimum requirement In prepared operations no food should have been given on the day of operation at all, except possibly for an afternoon list, when a cup of tea and a small quantity of carbohydrate could be allowed in the early morning A rapid smooth induction will help to avoid this complication, but the patient will almost certainly vomit on recovery, if the stomach is full

Treatment—Watch that a patient does not become too light during the operation, the signs of impending vomiting being salivation, pallor, swallowing, and rapid respirations

If vomiting occurs, turn the patient's head to one side, lifting one shoulder and lower the head of the table Suck out the pharynx or if suction is not available use swabs When the pharynx is cleared rapidly deepen the anæsthetic, keeping the patient's head low *Do not* go back and use ethyl chloride again Continue with ether

If as a result of vomiting an episode of respiratory obstruction and anoxia of any marked degree has occurred, it is well to consider, in the case of a non-urgent operation, postponement of the procedure particularly in a poor-risk patient

Ether Convulsions—

1 *Light Ether Convulsions*—These usually occur in a toxic child running a high temperature and are in the nature of the convulsions which may occur in these children without the incident of an anæsthetic The latter may owing to some degree of hypoxia during induction, act as a trigger mechanism to start the fit

2 *Deep Ether Convulsions*—These carry a much more serious prognosis and are of uncertain aetiology, as witness the many causes which have been given by various authors —

a Ether overdose
b Hyperthermia, either of the patient or operating theatre
c Aldehyde or peroxide impurities in the ether
d Atropine overdose
e *Toxæmia*
f Calcium deficiency
g Cerebral congestion
h Carbon-dioxide accumulation, or deficiency
i A tendency to convulsions in the patient
j Kemp[1] maintains that they are due to hypoxia of the cerebral cells Whatever the cause, they are a frightening condition to deal with and demand prompt treatment

Treatment —

1 Stop the ether

2 Fill the bag with oxygen, clamp the mask on the patient's face and inflate if possible

3 Inject cautiously 1–2 ml of 5 per cent thiopentone (sufficient only to control the convulsions)

4 If the arm movements preclude venepuncture, give intramedullary or rectal thiopentone (1 g /50 lb body-weight)

5 Continue to oxygenate the patient until normal respiration is established intubating if necessary

SIGNS AND STAGES OF ANÆSTHESIA

General anæsthetics exert their chief action on the central nervous system, and through this action modify every system

They have other less important direct actions on systems other than the C N S Their action on the C N S is depressant, producing unconsciousness and abolishing reflexes

Their first action is on the highest centres judgement is impaired and inhibition is lessened Then they act on the mid-brain, which is involved in the completion of reflex arcs by which the individual reacts to noxious stimuli Thus he may show a preliminary stage of excitement before being depressed—exaggerated reflexes

Certain centres are excited directly in some cases by the drug before being paralysed (e g respiratory centre with ether), later still there is depression of the spinal cord, and death is

finally caused by asphyxia from paralysis of the respiratory centre, except occasionally, in early chloroform administration, from vagal inhibition

By the action of the anæsthetic agent on the various centres and reflexes, phenomena are produced, the study of which enables a competent anæsthetist to judge accurately at any moment the depth of anæsthesia present

The depth of anæsthesia can be judged fairly accurately by a continuous observation of the respiration Experience is needed before this can be done, and a beginner must constantly check an opinion so formed, by a study of the state of other reflexes

Even the experienced anæsthetist cannot afford to dispense with these other checks, for unless the respiration and dosage during the whole administration are carefully watched, the phenomena of respiration seen during light and dangerously deep anæsthesia may be confused

Further, owing to emotional excitement and the reflex action due to the irritation of the larynx by the vapour, and those reflexes due to operative interference the respiratory phenomena are often so modified that other signs of the depth of anæsthesia must be utilized

However it remains true that the anæsthetist should watch the respiration above all things, especially when it is remembered that if the patient is going to die because of the anæsthetic it will be from anoxia in almost all cases He should be conscious of each respiratory movement of the patient and recognize at once the slightest change in the character of the breathing

It is customary to divide the period between the commencement of the induction and the point of death into the *four stages* (1) Analgesia (2) Delirium, (3) Surgical anæsthesia, (4) Respiratory paralysis

This can be shown in the form of a chart (*Fig* 43), with the changes in intensity of certain selected nervous activities and reflexes marked on it Furthermore, Stage 3 is subdivided into four planes

Stage 1—During the first stage, that of *analgesia* there is progressive decrease in reaction to painful stimuli and

progressive loss of consciousness, the latter becoming complete at the end of the stage

In the first stage the patient is generally co operative It is often difficult to draw a sharp line between the end of the first stage and the beginning of the next

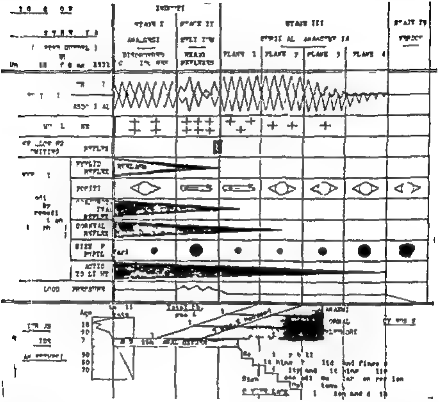

Fig 43 —The stages of anæsthesia

Stage 2 —The second stage is known as *delirium*, this may be merely potential or manifested by incoherent talk or struggling During this stage the patient is unconscious, and will subsequently remember nothing that has happened

Respiration is usually irregular, with some swallowing

Perhaps a better name for this stage would be that of *exaggerated reflexes*, for although the patient may become turbulent, or remain peaceful depending on several factors any slight stimulus will evoke an exaggerated reflex which will in turn produce other reflexes and so struggling may

take place Gentle restraint is necessary, for if it is applied forcibly the exaggerated reflex response will only make matters worse

Stages 1 and 2 are together called the '*induction period*'

Stage 3—Stage 2 passes into Stage 3 when muscular depression is sufficient to prevent the patient from moving his limbs in response to stimuli This level marks the onset of surgical anæsthesia and is recognizable by —

1 The onset of automatic respiration (especially if previously irregular)

2 Loss of the eyelid reflex—closing of the eyes evolved by retraction of eyelid

Only in the third stage should surgical operations be performed This stage is extensive, and is subdivided into four planes —

Plane 1 is characterized by progressive decrease both in the range of excursion of movements of the eyeballs, and in the rapidity of these movements—which commenced in the second stage—until at the end of this plane the eye comes to rest in the central position

Plane 2 is shown when the eye is in a central position, and there is complete function of the intercostal muscles and the diaphragm, for in

Plane 3 a progressive decrease in thoracic respiration commences, ultimately leaving only the diaphragm to carry on the respiration at the commencement of

Plane 4, and finally at the end of this plane and the commencement of *Stage* 4 respiratory effort is absent

Stage 4—In this stage the heart still beats and the patient will remain alive if kept adequately oxygenated by artificial respiration In time enough of the anæsthetic will be excreted to allow the respiratory centre to recover, and initiate respiratory movement on its own account

On general principles, the patient should be reduced to the minimum state of depression necessary for the operation in hand to be performed to the surgeon s satisfaction

In the main this will depend on the amount of muscular relaxation required, for the deeper the anæsthesia the more the relaxation obtained This will be chiefly noticeable in

operations on the abdomen, for the protective reflex response shown by rigidity of the abdominal muscles prevents the surgeon from carrying out his work, especially in the upper abdomen if the anæsthetic is not deep enough

Other Signs—There are other signs which may help to determine what stage and plane the patient is in, but these are not so very reliable under certain usual conditions of anæsthesia They are (1) Size of pupil, (2) Conjunctival reflex (3) Corneal reflex

The Size of Pupil is greatly modified by morphine, which is often given before general anæsthesia, and in the first stage by apprehension In Stage 1 it will be normal in size, in Stage 2 probably dilated to some extent

In the early part of Stage 3 it will gradually decrease in size to the point of maximum contraction at the end of the first plane, and thereafter will commence to dilate until in the fourth plane it will be fully dilated, and may show an irregular outline

The Conjunctival Reflex, a brisk closure of the eyelids elicited when the conjunctiva is touched, especially towards the inner canthus is present until the end of Plane 1 in Stage 3

The Corneal Reflex is elicited similarly by momentarily touching the cornea and obtaining the same response This disappears at the end of Plane 2 in Stage 3

However these signs are variable—especially the size of the pupil for morphine in normal dose may keep the pupil pin point, even at the end of Stage 3 Moreover injudicious use of the corneal and conjunctival reflexes may lead to serious eye trouble

Finally, the reaction of the pupils to light, obtained by closing both eyes for 10 seconds and then shining a bright light into one and noting the contraction of the pupil should always be present It disappears towards the end of Stage 3 and will be noticed to be getting more sluggish as Stage 3 progresses

The Blood pressure—During the second stage this may be raised slightly owing to increased reflex response to stimuli and then in the third stage it will show a normal 20 mm Hg drop—such as may obtain in natural sleep The pressure will

remain level, if there is no shock present, until the fourth stage, when the depression of the vasomotor centre, together with the loss of all muscular tone, will cause it to fall suddenly

It should be noted, in passing, that even while a patient is in the third stage, any severe stimulus may lighten the anæsthesia, and so there may be a return of some of the reflexes, without decreasing the amount of anæsthetic This will be more appreciated when it is known that the vomiting centre is stimulated at the end of Stage 2, so that if the patient is kept too near the beginning of Stage 3, a severe stimulus may cause vomiting, with perhaps serious results

CHLOROFORM*

Chloroform, a colourless liquid with a sweet agreeable odour, not as volatile as ether—not inflammable, heavier than air Depresses the circulatory and respiratory centres, highly toxic, does not irritate respiratory tract, but the liquid may burn the skin Customary to use in amber-coloured drop bottle

Use very rarely justified with present-day anæsthetic agents available In country districts its use is more often justified

Has the advantage of needing only a low percentage in inspired air to cause anæsthesia and relaxation, and induction of anæsthesia is relatively pleasant for the patient

It is not irritating to lungs

Administered from a drop-bottle on to a metal mask covered with a towel, the mask being kept off the face at one point to admit plenty of air

Percentage in inspired air 3–4 per cent, must not be allowed to vary from one moment to the next Recovery uncertain from overdose Usually used by *open method* or by *vapour method* (Junker's inhaler)

THIOPENTONE SODIUM

This drug, given as a 2½–5 per cent solution intravenously, has become fairly universal as a method of induction for anæsthesia This is because of its ease in administration and the pleasant subjective sensation for the patient There is no

* From Anæsthetic Notes for Medical Students University of Otago Medical School

feeling of asphyxia, but a sudden black-out or feeling of drifting away' It is particularly useful where repeated anæsthetics have to be given, the patient usually having no fear of subsequent inductions

Technique of Administration —

1 The dry powder is mixed with its ampoule of distilled water, using a wide-bore mixing needle, and the resulting solution drawn up into a 20-ml syringe, preferably with an eccentric nozzle

2 A fine bore needle (20 gauge) with a short bevel is affixed to the syringe

3 The patient is told what is to happen and his arm is examined for a suitable vein

The most suitable veins in order of preference are —

a A prominent vein on the forearm

b Antecubital veins preferably on the lateral side away from the brachial artery

c Veins on the dorsum of the hand

d Veins on the dorsum of the foot

e External jugular veins (only as a last resort)

4 The patient's arm is placed comfortably on a padded armboard at an angle of 45° to the body, and a rubber tourniquet applied to the upper arm

5 If the veins are small ask the patient to open and close his fist, rub the arm with spirit or 'milk' the veins firmly towards the upper arm

(*N B* —The veins become more prominent under any form of general anæsthesia so once a few ml of thiopentone are given, venepuncture becomes easier)

6 Choose a vein that is firmly anchored in fat rather than a prominent one that will roll away from the needle

7 With the syringe held at a narrow angle to the skin, puncture the latter alongside the vein, then make another puncture to enter the vein and advance the point up the lumen for $\frac{1}{4}$–$\frac{1}{2}$ in

8 *Aspirate* to ensure that you are in the vein and give 2–3 ml of thiopentone slowly and *pause* This gives time to gauge the patient's sensitivity to the drug, and some idea of how much to give him

At this stage also, ask him if he experiences any pain down the arm (This should eliminate the danger of intra-arterial puncture)

9 Now proceed to give slowly a further 5–8 ml as required before gently inserting a lubricated airway into the mouth For a straight thiopentone anæsthetic further increments of 1–2 ml are given as required The beginner should remember that the airway requires as much attention as with an inhalation anæsthetic It is very easy for the tongue to fall back and obstruct the patient, without the anæsthetist being aware of it, until cyanosis appears

Signs of Thiopentone Anæsthesia —

Too Light —

a The patient moves a limb in response to surgical stimuli or shows a laryngeal stridor from the same cause

b The respiratory excursion increases markedly

Too Deep —

a Respirations fade away to zero

b The pupils dilate

c The patient becomes cyanotic

The anæsthetist learns by experience to steer a middle course between these two extremes

Maximum Dosage —Should not exceed 1–1½ g for an adult, as prolonged respiratory depression may result

Hazards —

1 *Extravenous Injection* —The patient complains of local pain and the fluid can be seen outside the vein Remove the needle, and if necessary apply hot foments to the limb, or inject a few ml of 1 per cent procaine

2 *Intra-arterial Injection* —May occur through using the vein on the medial side of the elbow, or striking an aberrant artery on the forearm When this catastrophe occurs the high pH of the thiopentone causes a prolonged spasm of the brachial artery, with resultant thrombosis and perhaps gangrene of the limb

Symptoms —

a The patient complains of 'pins and needles' in the hand

b The time to produce narcosis is prolonged

c Forearm and hand may blanch

Methods of Avoiding —

a Always palpate for an aberrant artery before venepuncture

b Avoid veins on medial side of elbow especially in the unconscious patient

c Wait for a few seconds after initial injection, and ask the patient about pain down the arm

Treatment —

a Leave the needle in the artery and inject 4 ml of 2 per cent, or 10 ml of 1 per cent procaine into the artery (or tolazoline 25–50 mg)

b Perform a brachial plexus block on the affected arm

c Institute a regime of anticoagulant therapy

d If the operation must proceed, use cyclopropane to promote vasodilatation

3 *Laryngeal Spasm* —This is particularly liable to occur at light levels with thiopentone often initiated by a surgical stimulus or a plug of mucus irritating the cords

Treatment —

a *Mild* —Give a few more ml of thiopentone and inflate the patient with oxygen, if he becomes apnœic

b *Severe* —Where the spasm is persistent and the patient is becoming markedly cyanotic, 50 mg of suxamethonium intravenously, and gentle inflation with oxygen will save the situation Many anæsthetists have said that the cords will relax before the patient succumbs, but this may not be so, particularly where the heart is defective

4 *Apnœa from Overdose* —It requires approximately 2–3 times the amount of thiopentone to stop the heart as to stop respiration Hence unless the anæsthetist has given a gross overdose the only treatment required is to inflate the patient gently with oxygen until respiration commences again

5 *Cough* —Is particularly liable to occur with thiopentone at light levels Give more thiopentone, or proceed to gas-oxygen-trilene etc

6 *Sneeze* —Liable to occur in eye operations Proper cocainization of the eye beforehand will usually avoid it

7 *Regurgitation* —If there is anything in the stomach it will be regurgitated into the pharynx and either aspirated or will initiate laryngeal spasm Hence it is particularly important

to ensure that the stomach is empty before inducing with thiopentone

Uses—Thiopentone has been used for all types of operation, but has finally found its greatest usefulness in the following cases—

1 As an inducing agent

2 For short cases, not requiring relaxation, or where the cautery is to be used e g, cystoscopies, orthopædic manipulations opening abscesses short eye operations, etc

3 In electroconvulsive therapy, and endoscopies (in conjunction with relaxants)

4 In 'sleep' doses as a supplement to spinal or regional anæsthesia

Contra-indications—This varies with the experience of the anæsthetist With a 2½ per cent solution it can be used with safety in small children and the very elderly, providing it is given slowly, and in small doses

It should *never* be used—

1 When the stomach contains food or fluid

2 In respiratory obstruction

3 In constrictive pericarditis

It should be used cautiously in—

1 The shocked, debilitated and the very elderly

2 Nose and throat operations where blood may be aspirated

3 Asthmatics

4 In Ludwig's angina

Miscellaneous—The Gordh or Mitchell needle (*see under* EQUIPMENT) is frequently used as a convenient method of giving intermittent doses of thiopentone It may also be given as a drip (usually as 0 1–0 25 per cent strength). The '*thiopentone drip*' *has rather gone out of favour* because of the frequently prolonged respiratory depression following its use

MACHINES AND GENERAL ANÆSTHETIC TECHNIQUES

I THE BOYLE MACHINE

Consists of—

A A stand or table

B Brackets for holding cylinders

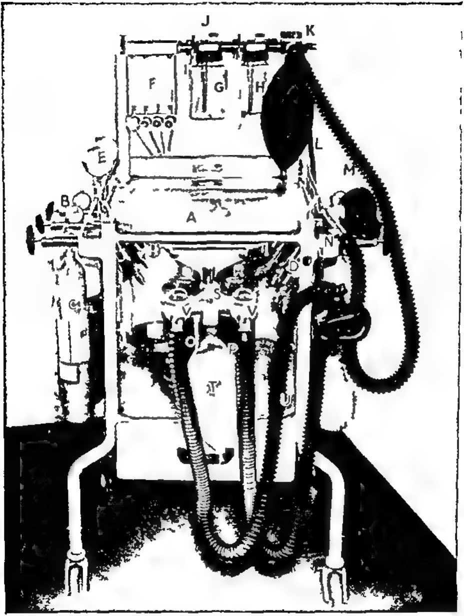

Fig 44—Th Boyle Mark II machine

C Gas cylinders
D Reducing valves
E Oxygen pressure gauge
F Flowmeters
G Ether vaporizing bottle

H Trilene bottle

I, J Lever and plunger for increasing flow of gases over the corresponding liquid

K Oxygen by-pass button

L Reservoir bag

M Single corrugated rubber tubing for semi open circuit

N Expiratory valve

In addition, for closed-circuit anæsthesia there may be a soda lime absorption unit

O Ether vaporizer of the 'baffle' type

P Soda-lime canister

Q Ether control knob

R Absorber control knob

S Expiratory valve

T Rebreathing bag

U Double tubing to patient for circle type circuit

V One-way valves

Fig 44 illustrates the Boyle Mark II machine

Semi open Circuit

(*Fig* 45)

The gases flow from the cylinder (A), and via the reducing valve (B), to the flowmeter (C) From here they pass to the vaporizing bottle (F), the amount passing over the contained fluid being controlled by the lever (D) and the plunger or hood (E) which deflect them down on to the surface

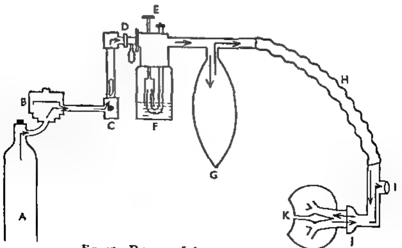

Fig 45—Diagram of the semi open circuit

Continuing on, most of the flow passes through the corrugated tubing (H) and face mask (J) to the patient's lungs (K) Some of the flow, however, passes in and out of the rebreathing bag (G) The returning gases pass mainly out via the expiratory valves (I), while some pass back into the rebreathing bag

Techniques —

1 *Gas and Oxygen* —The Boyle machine is not as good as the McKesson for administering a straight gas and oxygen A suitable technique for short cases is as follows —

a Pre set the oxygen flowmeter at 500 ml /minute

b Turn on 9–10 litres of nitrous oxide/minute

c Reassure the patient, holding the mask at ½–1 in from the face to avoid a feeling of suffocation

d Get him to relax and breathe easily, gradually lowering the mask on to the face

e When he is anæsthetized i e a tinge of cyanosis deflected eyeballs and regular respiration, reduce the nitrous oxide flow to 5–6 litres as required to keep him at the right level

Signs of being too deep —

1 Increased cyanosis

2 Jactitations

Signs of being too light —

1 Patient makes a movement, or shows signs of being awake

2 Prolongation of expiration is often a warning that he is becoming too light

2 *Thiopentone-Gas-Oxygen-Ether* —

a The patient is induced with thiopentone

b 1 litre of oxygen and 7 litres of nitrous oxide are turned on and the face mask applied to the patient

c After 1–2 minutes on gas and oxygen, the ether lever is brought to the zero mark

(*N B* —The zero mark varies for each machine and should be tested by sniffing at the distal end of the corrugated tubing and noting at what mark the first trace of ether can be detected)

d Advance the lever a division at a time as quickly as the patient will tolerate it without coughing If he holds his breath or coughs, the concentration must be reduced

e As the ether concentration is increased, the oxygen is increased to 2 litres, and the nitrous oxide reduced to 6 litres approximately

f When the lever is fully on, the plunger is lowered gradually, until finally the gases are bubbling through the ether When the patient will tolerate this concentration of ether, he will tolerate the surgeon's knife

g After 10–15 minutes in the average case (e g , appendicectomy) the concentration can be reduced, the amount required being gauged by the surgeon's requirements, and the signs of anæsthesia

h For the last 10 minutes of the operation the ether is reduced to a minimum and finally the patient is run on gas and oxygen alone

3 *Thiopentone–Gas–Oxygen–Trilene* —

a Induction with thiopentone

b Proceed as for gas–oxygen–ether with the following modifications

c Trilene being non-irritant, the concentration can be increased at a faster rate

d Increase the lever to the vertical position and leave there for 10–15 minutes then gradually reduce to 45° approximately It should be possible to maintain most patients on this concentration

(*N B* —On no account should it ever be necessary to lower the plunger when using trilene It is through trying to push it in this way that troubles occur in the way of tachypnœa, cardiac arrhythmia etc Regard it as a gas and oxygen anæsthetic with a trace of trilene as an adjuvant enabling one to use a higher proportion of oxygen in the mixture If tachypnœa occurs even with small concentration change to some other agent or give 20–25 mg of pethidine intravenously which will slow the rate of respiration (Dundee[7]))

e Trilene has a certain hangover effect It can be turned off intermittently and also well before the end of the operation, the patient continuing on gas and oxygen alone

Advantages of the Semi-open Circuit —

1 A simple and convenient circuit for the beginner

2 Very little resistance in the circuit Therefore suitable for children

Disadvantages —

1 Rather extravagant with gases

2 The patient loses more body heat than with a closed circuit

CLOSED CIRCUIT

(*Fig* 46)

Circle Type—The gases may be led in at any part of the circle They pass through the ether vaporizer (A) past the one way valve (B) and via the corrugated rubber tubing (C), to the patient (D) From the patient they return via the other tubing and one-way valve to the soda-lime absorber (F), and thence to complete the circuit, passing in and out of the rebreathing bag (G) on the way Excess gases escape via the expiratory valve (E)

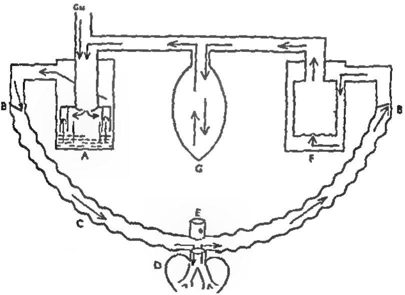

Fig 46—Diagram of the closed circuit

When the closed circuit was first used, the idea was to keep the circuit as leakproof as possible and supply very small amounts of gases sufficient to compensate for the unavoidable leaks For example gas flows of 500 ml of gas and 250 ml of oxygen per minute were not unusual It was soon realized however, that many patients were suffering from hypoxia using

this technique, as the oxygen was metabolized by the body but the nitrous oxide, being inert, tended to accumulate in the circuit It is now thought better to use flows of the order of 2 litres of nitrous oxide to 1 of oxygen, and to leave the expiratory valve slightly open Strictly speaking, it is a *semi closed* rather than a closed circuit Soda lime is used to absorb the carbon dioxide, which tends to accumulate using these smaller gas flows

Techniques —

1 *Thiopentone-Gas-Oxygen-Ether* —

a Induction with thiopentone

b Set the nitrous oxide at 5–6 litres and the oxygen at 1½–2 litres, and apply the mask to the patient's face with the expiratory valve open

c Run on semi open circuit for 3–4 minutes for two reasons —

i To eliminate air from the patient's lungs and the machine

ii A small accumulation of carbon dioxide allows of a quicker induction

d Reduce the gas flows to 2 litres of nitrous oxide to 1 litre of oxygen and close down the expiratory valve slightly

e Gradually introduce ether by advancing the control knob a notch at a time, keeping just below the coughing threshold for the patient

f Once the patient is taking ether well, turn on the soda lime absorber

g Maintain the patient at the depth required by the surgeon, being guided by the signs of anæsthesia

h Towards the end of the anæsthetic, turn off the ether and the absorber and return to semi-open circuit, so that the patient accumulates a little carbon dioxide and is breathing well before he leaves the theatre

2 *Thiopentone–Gas–Oxygen–Cyclopropane* —

a Induction with thiopentone

b Commence with nitrous oxide and oxygen on semi open circuit as above

c Turn on cyclopropane at 500–600 ml per minute, turn the nitrous oxide, and close the expiratory valve

d Turn on the soda lime absorber

e The cyclopropane flow is reduced over 5–10 minutes to a maintenance flow of 100-200 ml a minute After 20–30 minutes very small flows, e g, 50 ml a minute, will suffice to maintain its concentration in the circuit

Induction is rapid as it is a potent and non irritant gas Two points must be watched —

i *Arrhythmias* —A finger should be kept on the pulse and if the beat becomes irregular, either reduce the concentration or, better, change to some other agent It is doubtful if cyclopropane should be used in cases of auricular fibrillation

ii *The Ventilation of the Patient* —Cyclopropane is a marked respiratory depressant, and should the respiratory excursion become much reduced, the patient should be assisted until it is adequate There is danger in waiting for cyanosis to appear, with such a high oxygen concentration

f At the end of the operation the cyclopropane is turned off and a return is made to nitrous oxide and oxygen on semi-open circuit There are two reasons for this —

i To wean the patient gradually from his high oxygen mixture

ii To replace the volatile cyclopropane with more inert gases and avoid post-operative atelectases of the lung

Cyclopropane Shock' —This is a circulatory collapse,[3] accompanied by a slow pulse, which may occur after a cyclopropane anæsthesia It is thought to be due to carbon dioxide retention occurring during operation as a result of hypoventilation This results in overbreathing and hypocarbia post operatively Hence it should not occur if the patient is properly ventilated The treatment is by intravenous therapy

2 THE HEIDBRINK MACHINE

(*Fig* 47)

Consists of —

- A A stand to hold the gas cylinders
- B McKesson type reducing valves one to each pair of cylinders
- C Dry ' flowmeters
- D Soda-lime canister with two separate compartments
- E Control lever for soda lime canister

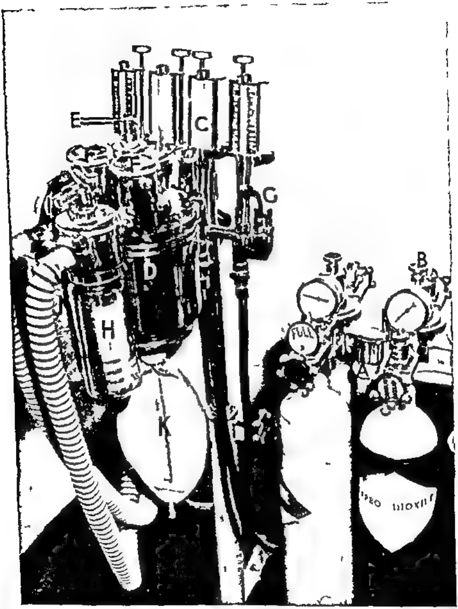

Fig 47—The Heidbrink machine

F One-way valves
G By-pass lever for oxygen
H Ether vaporizer of the wick type
I Control lever for ether vaporizer
J Humidifier
K Rebreathing bag

This machine was designed for closed-circuit anæsthesia, and because of its large dead space, is not suitable for children under 12 years, or patients with a poor vital capacity, i e, the elderly The gases pass from the humidifier side of the circuit to the patient, and the ether vaporizer is on the expiratory side

The soda lime control lever enables one to use the right or left chambers of the absorber (each containing 500 g of soda lime), or to cut it out of the circuit

Techniques—

1 *Thiopentone-Gas-Oxygen-Ether*—

a Induction with thiopentone

b Technique is as for closed circuit using the Boyle machine When introducing ether the concentration is gradually increased to mark 7 or 8 and can be reduced to mark 3-5 for maintenance

2 *Thiopentone-Gas-Oxygen-Cyclopropane*—Similar to the *technique with the Boyle machine*

McKESSON AND WALTON MACHINES

(*See under* DENTAL ANÆSTHESIA)

MISCELLANEOUS POINTS REGARDING MACHINES

When using gas machines of any type the anæsthetist incurs extra responsibilities, as the possibility of mechanical defects in the machine and flowmeters may occur and in all cases he must watch the patient's condition closely Flowmeters may be inaccurate, and the best guide is the colour of the patient Pressure gauges must be watched to see that cylinders do not run out

Cylinders—Particular care must be taken that the correct cylinders are fitted to their corresponding yoke Fatalities have occurred from the wrong gas being delivered to the patient The international colour code for gas cylinders recently agreed upon should help to eliminate this danger

Soda-lime—This is a mixture of 90 per cent calcium hydroxide with 5 per cent sodium hydroxide, with silicates to prevent powdering It is used to absorb the carbon dioxide carbonates being formed The granules are size 4-8 mark to lessen resistance in the circuit yet provide a good surface

area for absorption The canisters are of such a size as to contain the patient's tidal air in the interstices during expiration A 1-lb canister of soda-lime will last for 2 hours continuously, or 4–5 hours intermittently before becoming exhausted Some makes have an ethyl violet indicator incorporated which turns blue with carbon dioxide It is the anæsthetist's duty to see that his soda-lime is fresh before starting

Ether Vaporizers —The 'baffle' type causes less resistance than the wick type The latter tends to become saturated with water vapour further increasing the resistance in the circuit

Waters' 'To-and-Fro' Absorber (*Fig* 48) —This consists of a metal canister containing soda-lime, to one end of which is attached a rebreathing bag and to the other a face mask An expiratory valve is incorporated and the gases are led in via the metal fitting at the anterior end of the canister The

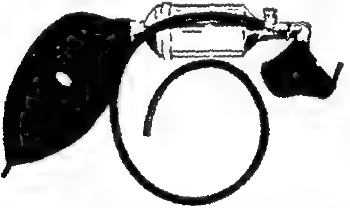

Fig 48 —The Waters to-and fro absorber

gases instead of moving in a circle, pass to and fro through the absorber to the rebreathing bag, there being minimal resistance in the circuit The canister is run from a suitable gas machine, and techniques similar to those already described can be employed To build up carbon dioxide at the end of the operation the canister is removed and the bag attached directly to the anterior metal fitting

Advantages —

1 Simplicity
2 Minimal resistance in the circuit
3 Warmed gases supplied to patient

4 Suitable for children, using small canisters, as the dead space is small

Disadvantages —

1 It is difficult to balance the canister alongside the patient's head

2 Ether cannot be used owing to the small gas flows Mainly used for cyclopropane anæsthesia

Advantages of Closed Circuit —

1 Warmed gases supplied to the patient

2 Economy

3 Reduced fire and explosion risks

Disadvantages of Closed Circuit —

1 Increases resistance and dead space

2 Not suitable for children (except with specially designed apparatus)

3 Danger of carbon dioxide accumulation if soda lime is exhausted

4 Trilene cannot be used in a closed circuit with soda lime absorber as the latter causes decomposition to dichloracetylene and may result in cranial nerve palsies

TECHNIQUES USING RELAXANTS

Introduction —The modern concept of anæsthesia is that of a triad (1) Narcosis, (2) Analgesia, (3) Relaxation, on a basis of apnœa (Gray)[4] Previously one agent, e g chloroform was used to produce all three components but was toxic to the patient We now aim at using three separate, non-toxic components to produce the same result, but with less harm to the patient We use barbiturates to produce narcosis pethidine and related drugs for analgesia, and the relaxants to produce relaxation

Techniques —

1 *Thiopentone–Gas–Oxygen–Curare*[5]—

a Induce with thiopentone

b Inject 2–2 5 mg /stone of *d* tubocurarine chloride (This dose should be reduced in the obese and the unfit patients)

c Inflate the patient with oxygen and *wait 2 minutes* before attempting intubation

d Intubate with a cuffed tube and inflate the cuff

e Start controlled respiration using 2 litres of nitrous oxide to 1 litre of oxygen, with a semi closed circuit and soda lime absorber

f Repeat injections of *d*-tubocurarine chloride (5–7-mg doses) as required usually at half-hour to three-quarter hour intervals Time the last dose at least half an hour before the end of the operation

g Turn off the soda-lime absorber for the last few minutes of the operation

h If the patient's respiration is inadequate at the end, give gr 1/100–1/50 atropine intravenously and follow in 5–10 minutes with 1–2 5 mg of neostigmine

2 *Thiopentone–Gas–Oxygen–Gallamine* —

a Induce with thiopentone

b Inject 10–15 mg /stone of gallamine triethiodide

c Inflate the patient with oxygen and wait ½–1 minute for the full effect of the relaxant

d Proceed as for curare It will be found that supplementary injections of 20–30 mg will be necessary at 20–30-minute intervals

3 *Thiopentone–Gas–Oxygen–Suxamethonium* (' Suxamethonium drip ')—Suxamethonium having such a short action, it is necessary to use it in the form of a drip for longer operations It is a useful technique for the elderly and poor-risk cases e g, obstructions (*see* EMERGENCY ANÆSTHESIA) as there is no prolonged depressant effect on respiration

a Mix 800–1000 mg suxamethonium in a 500 ml bottle of saline or Bart's solution and set up as a drip in the forearm

b Induce with thiopentone

c Inject 50–75 mg suxamethonium from another syringe

d Inflate the patient with oxygen and intubate as soon as the muscular twitches cease

e Institute controlled respiration with the same gas flows as for curare

f Wait until a diaphragmatic flicker appears on the rebreathing bag (this is an indication of how prolonged the suxamethonium effect is in that particular patient)

g Start the drip at 20–30 drops per minute and turn off at regular intervals, until diaphragmatic flicker returns

h Turn off the drip and the soda lime absorber when peritoneum is closed, and the patient will be breathing strongly as the skin stitches are put in If this technique is adhered to no troubles should be encountered from suxamethonium overdose [6]

(*N B*—Pethidine may be given as supplementary analgesia in these techniques in doses of 25–40 mg at half-hourly intervals)

ASSISTED AND CONTROLLED RESPIRATION

Introduction —Whenever relaxants are used, even in small doses, the tidal exchange of the patient is reduced, the peripheral areas of lung tissue are not fully expanded, and hence the patient s respiration should be assisted or controlled Controlled respiration is probably preferable, as it is difficult at times to keep in phase with assisted respiration, and it is difficult to be sure that adequate ventilation is being carried out

Production of Apnœa [7]—Younger anæsthetists brought up on relaxant techniques tend to forget that there are several factors producing the patient's apnœa —

1 Raising the threshold of the respiratory centre

a By premedication with morphine barbiturates, etc

b By the use of volatile anæsthetic agents, especially cyclopropane (Nosworthy in 1941 wrote a classic paper on controlled respiration using cyclopropane alone [8])

2 *Acarbia*—produced by hyperventilating the patient through the soda lime canister

3 A *fatigue* effect on the Hering-Breuer reflex produced by over-distension of the alveoli

Dundee has produced some evidence to show that using this technique prolongs the effect of barbiturates and relaxants [9] The longer-lasting effect of thiopentone may be due to a change produced in the *p*H of the blood making it more alkaline

Technique of Controlled Respiration —

1 The patient is induced a relaxant given, and a cuffed tube inserted

2 The set-up as shown in the photograph (*Fig* 49) is a useful one for carrying out controlled respiration The position of the rebreathing bag has simply been modified by the addition

of a length of corrugated rubber tubing, thus 'mobilizing' the anæsthetist for intravenous injections and allowing the bag to rest comfortably in his lap. For the short time that the patient is breathing on his own, the extra length of corrugated tubing would not seem to be detrimental.

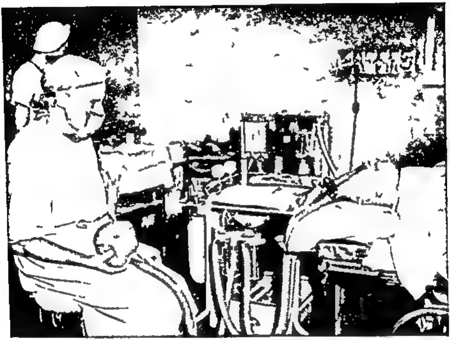

Fig. 49.—Carrying out controlled respiration.

3. Nitrous oxide 2 litres and oxygen 1 litre are turned on and the expiratory valve is adjusted so that the patient is adequately ventilated, the excess gases escaping via the valve. The soda-lime is turned on, and rhythmical compression of the bag commenced at 18–20 per minute. As we are working on positive pressures inside the chest (up to 10–20 mm. Hg) there is some interference with the thoracic venous pump. Hence the technique of squeezing the bag is important. A quick squeeze, a quick release, and then a pause with zero pressure in the bag. This will cause minimal interference with venous return, and therefore cardiac output—an important factor in the poor-risk patients.

Hypoventilation and Hyperventilation.—The anæsthetist should steer a middle course between under- and over-ventilating

his patient If in doubt, it is wiser to err on the side of hyperventilation, as the dangers to the patient are less A good idea of the amount of ventilation can be obtained by listening at the corrugated tubing while squeezing the bag

Hypoventilation —The patient tends to become cyanotic, to sweat, and to accumulate carbon dioxide

Hyperventilation —This causes an acarbia, and alters the *p*H of the blood both easily reversible Prolonged hyperventilation may cause oliguria and decreased urea clearance In addition it interferes with venous return and may reduce the cardiac output, as well as causing vasoconstriction of the cerebral vessels

Signs of Anæsthesia —The use of relaxants alters the signs of anæsthesia which were originally worked out by Guedel for open ether We now work on such light levels of anæsthesia, that unless we watch the patient carefully, and recognize the signs we may have him awake but paralysed, a tragedy which has occurred on more than one occasion [10]

Signs of Lightening of Anæsthesia —

1 The patient twitches a finger, wrinkles his brow, or starts to mouth on the tube

2 The patient commences to sweat (this may also be due to exhaustion of the soda lime absorber)

3 A tear-drop forms at either canthus

4 The patient commences to hiccup

Any of these signs indicate the need for more pethidine or thiopentone Even when these signs are lacking the anæsthetist knowing the length of time his various drugs act may deem it wise to give additional doses at regular intervals The need for more relaxant can be judged by the degree of resistance felt in the bag and the requirements of the surgeon

Traps for Beginners —When the surgeon complains that the peritoneum is tight and you feel that according to the drugs given, the patient should be well relaxed make sure that —

a The gall-bladder rest is not up , or

b The peritoneum is not anchored to one side by a drainage tube

(*N B*—Many surgeons do not realize that it is impossible to relax an abdomen which is already distended to the limit, e g, in intestinal obstruction)

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CHAPTER IX

MACHINES USED FOR CONTROLLED RESPIRATION

THE requirements for a mechanical respirator are —

1 It should reproduce as closely as possible the normal pattern of respiration

2 It should be sensitive to pressure changes in the chest, so that the change from expiratory to inspiratory phase and vice versa, occurs at a pre set pressure

3 It should indicate the occurrence of —

a Obstruction to the patient s airway

b Leaks in the circuit

c Mechanical failure of the machine

4 It should be noiseless, sparkproof, and reliable

The indications for the use of a mechanical respirator are rather limited and most anæsthetists feel rather divorced from their patients when these machines are in action It is necessary to train another set of reflexes and become adjusted to their presence The patient also requires just as much if not more, attention from the anæsthetist, as when no machine is used

Advantages —They have the following advantages —

1 They enable the single-handed anæsthetist to give intravenous injections etc

2 They relieve him of the tedium of bag squeezing during long cases

Disadvantages —

1 Mechanical failure may occur

2 Hypoventilation may occur despite the fact that the machine is apparently functioning normally

3 The anæsthetist loses the feel of the bag and is not so easily able to anticipate the patient s requirements

TYPES OF RESPIRATORS

1 **Pump Types**.—These deliver a fixed volume of gases to the lungs, irrespective of the pressure developed.[1]

a *The Harrington-James Respirator* (*Fig* 50).—This consists of a concertina bag compressed by an electric motor, at a rate of 20/minute. There is a valve gear link mechanism, which allows changes in stroke volume to be made without stopping

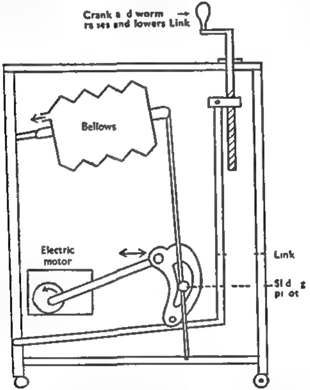

Fig 50.—The Harrington James respirator

the motor. A water manometer acts as a safety valve and indicates the pressures produced. The manometer can be pre-set to a peak value and pressures higher than this will cause the gases to bubble through the fluid and out through the overflow.

b *The Beaver Respirator*[2] (*Fig* 51).—This consists of a small electric motor, contained in a wooden case which alternately compresses and expands a concertina bag by means of a crank drive. On compression air is forced into the lungs, and on expansion the negative pressure opens an expiratory valve to allow the air to escape into the atmosphere. A separate valve

acts as a safety valve The pressures in the circuit are shown on a manometer A disadvantage is that the capacity of the bellows is fixed at 1400 ml and there is no way of adjusting the stroke volume (*N B*—The Beaver Mark II incorporates this modification) The respiratory rate is fixed at 14 or 18/minute

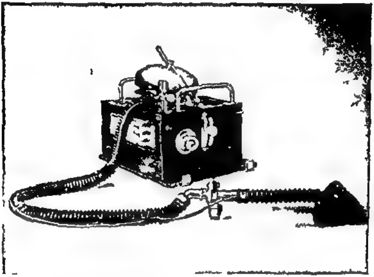

Fig 51—The Beaver respirator (Brit h Oxygen Gases Ltd)

2 Pressure-sensitive Respirators [3]—In these machines when a pre set pressure is reached, the supply of gases or air is interrupted and the intrathoracic pressure falls to zero The device which causes this 'cycling' effect may be a diaphragm actuating valve, a water manometer closing electrical contacts or actuating electrically operated valves

a *The Blease Pulmoflator* (*Fig* 52)—An example of the diaphragm-operated type The 'cycling' mechanism is operated by a spring and ratchet device Compressed gases enter the main chamber from the compressor in the base of the cabinet, and act on the outside of the bellows (A) thus inflating the patient s lungs While this is occurring the diaphragm is being displaced to one side, and at the crucial point the ratchet mechanism flicks over opening a valve and allowing the pressure in the main chamber to fall to zero Expiration occurs during this phase A spring pressing on the diaphragm causes it to move in the opposite direction until the ratchet

flicks over again, closing the valve, and restarts the inspiratory phase The maximum pressure in the chest is shown on a manometer and is controlled by a lever on the front of the

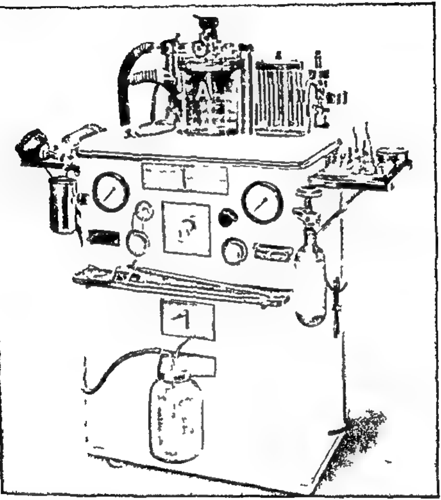

Fig 52 —The Blease pulmoflator (Blease Anæsthetic Equipment Ltd)

cabinet There are also knobs to control the length of expiration and inspiration A scale on the bellows allows the respiratory excursion to be measured

b The Aintree Respirator (*Fig* 53) —This works on the principle of a supply of compressed air in the jar forcing gases contained in the enclosed bag into the patient s lungs At a pre set pressure, the force overcomes a magnetic attraction

acts as a safety valve The pressures in the circuit are shown on a manometer A disadvantage is that the capacity of the bellows is fixed at 1400 ml and there is no way of adjusting the stroke volume (*N B*—The Beaver Mark II incorporates this modification) The respiratory rate is fixed at 14 or 18/minute

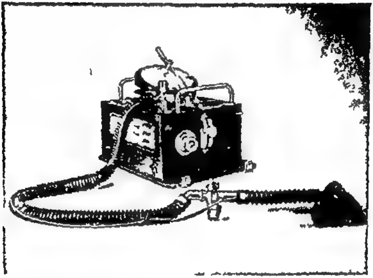

Fig 51 —The Beaver respirator (British Oxygen Gases Ltd)

2 **Pressure-sensitive Respirators**[3]—In these machines, when a pre set pressure is reached, the supply of gases or air is interrupted, and the intrathoracic pressure falls to zero The device which causes this cycling effect may be a diaphragm-actuating valve, a water manometer closing electrical contacts or actuating electrically operated valves

a *The Blease Pulmoflator* (*Fig* 52)—An example of the diaphragm operated type The cycling mechanism is operated by a spring and ratchet device Compressed gases enter the main chamber from the compressor in the base of the cabinet and act on the outside of the bellows (A), thus inflating the patient s lungs While this is occurring the diaphragm is being displaced to one side and at the crucial point the ratchet mechanism flicks over opening a valve and allowing the pressure in the main chamber to fall to zero Expiration occurs during this phase A spring pressing on the diaphragm causes it to move in the opposite direction until the ratchet

CHAPTER X

SPECIAL ANÆSTHETIC TECHNIQUES

General.—Induction is usually with thiopentone given intravenously (*see under* THIOPENTONE, p 40) If intubation is required, it is carried out by one of the methods previously described, and the anæsthetic is continued with gas and oxygen, cyclopropane, trilene, etc, as required

When relaxation is necessary, a relaxant is given and the breathing assisted or controlled At the conclusion of the operation, if the respiratory excursion is inadequate, gr 1/50–1/100 of atropine is given followed by 1–2 mg of neostigmine Some anæsthetists mix the atropine and neostigmine in one syringe but this does not give time for the atropine to block the parasympathetic effect of the neostigmine, and cases of cardiac arrest have occurred

The endotracheal tube if present, is gently removed, not forgetting to deflate the cuff first, and the pharynx is sucked dry of mucus and secretions A lubricated pharyngeal airway is placed in position and the anæsthetist controls the patient's airway until he has handed over to a competent nurse who accompanies the patient back to the ward

The best position for the patient to return to the ward is in the semi-prone one with the upper knee bent at a right angle, the so-called tonsil position In this way if any vomiting or bleeding occurs it will not be aspirated into the trachea

I ABDOMINAL[1]

1 Minor Operations.—

Appendicectomies Femoral Herniæ Inguinal Herniæ, etc

Adults.—

a Induce with 0 3–0 5 g of 5 per cent thiopentone

b Continue with gas–oxygen–ether or cyclopropane sequence on open or closed circuit The occasional difficult appendicectomy will require more relaxation and the technique used for major abdominal operations can be followed (*see* p 98)

opens a valve, and allows the compressed air to escape The flow of compressed air through a venturi tube produces a slight negative pressure, and aids the flow of gases from the patient When the pressure falls, the attraction between the magnet and a metal plate closes the valve and the inspiratory phase starts again The *respirator is supplied with a separate compressor*

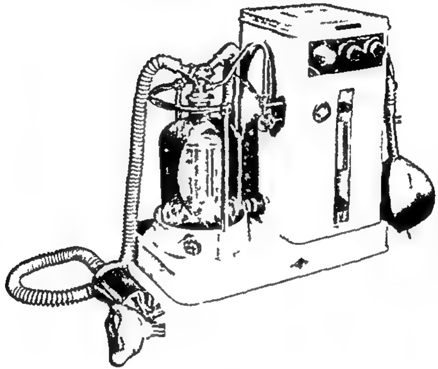

Fig 53 —The Aintree respirator (Medical and Industrial Equipment Ltd)

unit which is meant to be kept outside the theatre The motor and switch of the latter are not sparkproof, and would constitute an explosion risk

Any reader interested in the detailed construction and working of these machines is recommended to read an excellent review article in the *British Journal of Anæsthesia* (March 1954) by Mushin and Rendell Baker

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Indications for more curare —

i The obvious ones of the surgeon complaining of tight muscles, peritoneum, etc

ii The 'feel' of the bag, which becomes harder to squeeze as the effect of the curare wears off

Indications for more pethidine or thiopentone —

1 'Mouthing' or tongue movements by the patient

2 Brow wrinkling or eyelid movements

3 Movements of fingers or hand

The problem of tight peritoneum at closure When the surgeon complains that he is having difficulty in closing, and the anæsthetist is unwilling to give more curare, there are two solutions —

i Give a small dose (20–40 mg) of gallamine triethiodide which, having the same action as curare can still be reversed by neostigmine and has a shorter action

ii Give 0 05–0 1 g thiopentone intravenously, which will often soften the peritoneum sufficiently to allow closure

Alternatives to the above technique are to use gallamine triethiodide instead of curare (80–100 mg gallamine triethiodide = 15 mg curare and the maximum effect lasts 20–30 min) or to use cyclopropane 100–150 ml per minute and oxygen 500–1000 ml per minute in closed circuit as the covering agent, instead of nitrous oxide Care should be taken to wean the patient on to gas and a lower oxygen percentage towards the end

b Cholecystectomy Laparotomy Colostomy, Lumbar Sympathectomy Abdomino-perineal Resection —A similar technique is used In the case of abdomino-perineal resection the alternative of a spinal anæsthetic in conjunction with thiopentone and gas and oxygen to produce narcosis is often used In either case one or two pints of blood are usually given during operations

II ORTHOPÆDIC

1 *Routine Limb Operations* —Either —

i Induce with thiopentone, and maintain on semi-open circuit with gas–oxygen–trilene, or intravenous pethidine as required

c When the muscle layers are sewn up, wean the patient on to gas 75 per cent and oxygen 25 per cent

Children —Thiopentone or gas and oxygen induction, and maintain on gas, oxygen, ether, or cyclopropane, etc

2 **Major Operations** —

a *Gastrectomy* [2]—The patient usually has a Ryle s tube in position and this is aspirated before induction

i Induction with thiopentone and 50–75 mg suxamethonium A cuffed endotracheal tube is inserted after spraying the cords and trachea with 2 ml of 4 per cent lignocaine and inflation with oxygen

ii The patient is then connected to the machine and breathes 25 per cent oxygen and 75 per cent gas on his own, while he is wheeled in, positioned, and a drip or Gordh's needle inserted in the left arm (*N B* —The patient may be intubated on curare or gallamine triethiodide and the spraying omitted, but this necessitates another person ventilating the patient while the preparations are completed)

iii While the surgeon is scrubbing up 20–30 mg of curare (2–2 5 mg /stone) is given, and controlled respiration started An almost closed circuit is used with gas flows of 1 litre of oxygen to 2 litres of nitrous oxide the excess gases escaping from the partly opened expiratory valve

Further doses of 5–7 mg of curare are given at 30–40-min intervals depending on the patient s reaction The last dose is timed so that there is an interval of at least 20–30 min before the completion of the operation and the administration of neostigmine If this is not done the patient may become re-curarized as the effect of the neostigmine wears off

iv Five minutes before the surgeon starts pulling down on the fundus of the stomach 20–25 mg of pethidine is given This prevents the distressing hiccup which often develops at this stage

v Once the muscle layers are sewn up the carbon dioxide absorber is turned off and atropine and neostigmine are injected intravenously The patient should be breathing strongly by the time the last skin stitch is inserted

have the patient deep enough so that there is no gagging on the tube Any of these factors may produce increased venous congestion in the operation field and increase the surgeon's difficulties considerably It is often a help in this respect to have the patient in the anti Trendelenburg position with a foot-rest and a strap above the knees The operation of thyroidectomy will be used to describe the technique for these anæsthetics

Thyroidectomy[3]—

a Induction with thiopentone

b Intubation with 50 mg suxamethonium and spraying cords and trachea with 4 per cent lignocaine This spraying should be thorough, preferably with a Macintosh spray, down to the carina, so that the tube lies peacefully in the trachea

c Maintenance is by gas and oxygen with additional trilene or pethidine as required A Gordh s needle inserted in the dorsum of the foot is useful for intravenous injections, the arms being inaccessible

If the operation is prolonged it is advisable to reduce the amount of pethidine given towards the end and to use trilene as the adjuvant[4] Too much pethidine will cause post-operative respiratory depression

Thyrotoxicosis —This should be brought under control by pre-operative medical treatment

Routine Thiouracil should be avoided if possible, as it increases the vascularity of the thyroid gland Hence it is only used if other methods fail

The usual routine is that of bed rest, sedatives, and Lugol s solution for the optimum time e g, 10 days pre operatively and 10 days post operatively The patient's weight should increase and the sleeping pulse and B M R fall

A suitable premedication when the patient is prepared is amytal gr 3 the night before, and omnopon gr 1/3 and hyoscine gr 1/150 1½ hours pre-operatively The induction and maintenance are as before

Intubation —There are two schools of thought regarding intubation for thyroidectomy One maintains that intubation causes an increased incidence of post-operative tracheitis and

Or *b* Induce with thiopentone, and maintain on closed circuit, with cyclopropane and oxygen (if no diathermy is being used) The former technique will be found to be the most generally useful for orthopædic work owing to the frequent use of diathermy, X-ray machines etc

Tourniquets The anæsthetist should make himself responsible for these as a double check He should note the time of application and remind the surgeon when the time limit has expired (40 minutes for the upper limb, 60 minutes for the lower limb) He should also note that the tourniquet has been removed before the patient leaves the theatre

2 *Operations on Shoulder and Hip, Arthroplasties, Nailing Operations* —

a Induce with thiopentone, and maintain with gas oxygen, and trilene or pethidine

b The following *lignocaine cocktail* can be injected in the line of the incision and down to the joint capsule or bone after induction —

2 per cent lignocaine (plain)	20 ml
Normal saline	60 ml
1/1000 adrenaline	0 4 ml
Hyalase	½ ampoule

This solution ensures a practically bloodless field and reduces the painful impulses to a minimum thus lessening the amount of general anæsthetic required The hyalase ensures its spread along fascial planes, while the adrenaline reduces its absorption into the blood-stream

c The greatest shock occurs at the moment of dislocation of the hip and it is a wise plan to give 20 mg pethidine 5–10 min before this is done Some anæsthetists give a small dose of relaxant to help the manœuvre of dislocation, assisting respiration during this time

3 *Laminectomies Bone graft to Spine*—*See under* NEUROSURGICAL p 138

III HEAD AND NECK

Intubation is normally desired to give the surgeon unimpaired access to the operation field It is essential to have a quiet uneventful induction and maintenance a clear airway, and to

trolley, and with a nurse holding it, to instil the fluid down each side of the septum

In addition a little local anæsthetic should be injected into the columella

b The patient is then induced with 0 4–0 5 g of 5 per cent thiopentone followed by 80–100 mg of gallamine triethiodide and inflated with oxygen An oral endotracheal tube is inserted and the patient's respiration assisted until the tidal exchange is sufficient (usually 4–6 min)

Packing the pharynx The pharynx is packed with 2-in gauze packing, paraffined, or moistened with clean tap water and wrung out Less trauma is inflicted if, standing at the patient s head and using a Macintosh laryngoscope to hold the tongue forwards, the packing is placed in position with the fingers rather than with forceps

To test the effectiveness of the packing Screw down the expiratory valve and squeeze the bag of the machine If the packing is airtight it will certainly stop any blood from trickling down the trachea

c Maintenance is by gas, oxygen, and trilene, and the patient should cough on removal of the tube

d Thorough oropharyngeal toilet should be carried out at the end the patient being placed in the semi-prone position before packing and tube are removed

Antrostomies, Caldwell Luc Operation, Repair of Fractured Nose—A similar technique can be used, with the omission of the cocainization of the nasal fossæ

Tonsillectomies[5, 6]—

Adult—

a Induction with 0 4–0 6 g of thiopentone and 80–100 mg of gallamine triethiodide, and inflation with oxygen

b A nasal endotracheal tube is inserted If the patient is operated on in the *Rose* or hyperextended position no packing is required

c Maintenance is by gas, oxygen, and trilene or pethidine in semi-open circuit Some surgeons inject a little local analgesic into the pillars of the fauces maintaining that the operation is rendered more bloodless and the patient can be run at a lighter level of anæsthesia

does not warn the anæsthetist if the surgeon is damaging a recurrent laryngeal nerve during operation The other school maintains that these disadvantages are outweighed by the freer airway and lack of oozing in the operative field On the whole *I think it is wiser to intubate The cords can always be* inspected after extubation Some surgeons prefer the patient to cough before they close the muscle layers This can be accomplished by turning on the ether bottle for a few breaths

IV EAR, NOSE, AND THROAT

The majority of E N T operations require intubation, and in these cases it is dangerous to spray the larynx and trachea because of the likelihood of blood being aspirated during operation or post-operatively

Nasal Operations —*Submucous Resections Turbinectomies Polypectomies* —

a A thorough cocainization of the nasal fossæ should be carried out to give a bloodless field The reason most surgeons have in the past objected to general anæsthesia in these cases has been the increased vascularity

The instillation is best carried out by the postural method, which avoids painful packing for the patient

Technique Moffet s method[5]—The following solution is made up —

10 per cent cocaine	1 ml	6 ml
1/1000 adrenaline	1½ ml	
1 per cent soda bicarb	3½ ml	

i The patient lies on his left side with a pillow under his shoulders and the head inclined at 45° By means of a small syringe and a blunt wide bore needle, 1 ml of the mixture is *instilled into each nostril and left for 5 minutes*

ii The same is repeated with the patient on the right side

iii The patient is then put in the knee elbow position with head and neck fully flexed and 1 ml instilled into each nostril as before

iv Finally the patient blows his nose to expel any excess fluid

A quicker method which suffices for a submucous resection is to hyperextend the patient s head over the end of the

Œsophagoscopy ; Gastroscopy —

a Induction with 0 4–0 6 g thiopentone and 80–100 mg gallamine triethiodide (approx)

b Intubation with a cuffed tube which is inflated

c Maintenance with gas 5 litres and oxygen 2 litres (semi open circuit) plus trilene if required and assisted respiration until tidal exchange is sufficient

(*N B* —If the operation is known to be of short duration, suxamethonium is probably preferable to gallamine triethiodide—an initial dose of 50–75 mg is given for intubation, the syringe left in the vein, and serial injections are given as required)

V EYE[10]

A considerable amount of eye surgery is performed under local analgesia owing to the danger of post-operative vomiting or coughing raising the intra-ocular pressure and expressing aqueous or vitreous, e g , following cataract operations, etc

These local techniques will not be discussed here as they are in practice invariably performed by the ophthalmic surgeon

It is important when a general anæsthetic has to be given to have a smooth induction and maintenance leading to an uncomplicated recovery period Thiopentone is much favoured, because it keeps a 'still eye' and there is little if any post operative vomiting[11] One drawback is the liability of the patient to cough or sneeze during the administration This is lessened by the instillation of a little cocaine into the eye pre operatively

Enucleation, Entropion and Ectropion , Pterygium, Tarsorrhaphy , Adult Squints , Dacryocystectomy , Detached Retina , Dacryocystorhinostomy —

a Thiopentone induction

b Intubation with 50–75 mg of suxamethonium and spraying the cords and trachea with 4 per cent lignocaine

c Maintain on gas–oxygen and trilene or pethidine (semi-open circuit)

d 10° anti Trendelenburg position with a foot-rest helps to reduce the ooze

Paracentesis , Iridectomy , Trephining —For short intra ocular operations Dr Sheila Anderson recommends a

Children [7]—*See under* ANÆSTHESIA IN CHILDREN, p 143

Mastoidectomy, Fenestration—Here the aim is to reduce oozing as much as possible and a quiet induction and maintenance are essential Some anæsthetists use hypotensive drugs, particularly for fenestrations, where oozing beneath the flap may ruin the operation

a Induction with thiopentone

b Intubate with 50–75 mg suxamethonium and spray cords and trachea fully with 4 per cent lignocaine

c Maintain on semi-open circuit with gas–oxygen and trilene or pethidine and with the patient in the anti-Trendelenburg position

Cyclopropane or gallamine triethiodide are contra indicated as they cause increased oozing It is also important to watch that no CO_2 accumulation occurs as this is another cause of increased vascularity The rebreathing bag should be emptied from time to time to prevent this

Laryngofissure [8]—

a Thiopentone induction, following a cricothyroid puncture and insertion of 2 c c of 4 per cent lignocaine into the trachea

b Intubation with a 12-in No 5 uncuffed tube through one nostril The tube must be of this length to ensure that the tip lies beyond the operative field

c Maintenance with gas, oxygen, and trilene or ether

d The surgeon cuts down on to the tube and then packs around it to maintain a gas tight fit He must be sure that the field is dry and the pack removed before closure

Total Laryngectomy [9]—

a Cricothyroid puncture with 2 c c of 4 per cent lignocaine

b Thiopentone induction and the passage of a large-sized cuffed tube into the trachea

c Maintain with gas oxygen, trilene or pethidine

d As the upper end of the larynx is freed the upper end of the tube is cut brought out through the neck and reconnected to the machine

e Once the larynx is dissected free it is threaded off the tube

f At the conclusion of the operation, careful tracheo bronchial toilet is carried out and the tube removed A tracheotomy tube is inserted in its place

b Maintenance with gas, oxygen, and trilene or pethidine, in semi-open circuit

c If the surgeon can be persuaded to inject the ' lignocaine cocktail ' (*see* p 100) into the operation area, this infiltration will give the relaxation required, and a bloodless field, and will allow the patient to be run at a much lighter level of anæsthesia

These operations usually last a considerable time and the blood-loss is often quite marked The difference in the condition of the patient using this technique is well worth the extra 5 minutes it takes to inject the solution Some anæsthetists are not happy about using adrenaline with trilene, the suggestion being that the combination may predispose to ventricular fibrillation In this case an alternative is to use pethidine or to delay turning on the trilene until some 10 minutes after the adrenaline injection

Or *a* Induction with thiopentone

b Maintenance with gas and oxygen (semi open or closed circuit) and just sufficient relaxant to relax the perineal muscles (40–60 mg gallamine triethiodide)

There is much more oozing with this method, as there is with all relaxants

Rubin's Test —Here there are two problems First, a non-explosive mixture must be used in the X-ray department , and secondly, it is often carried out in the dark to allow preliminary screening to be performed

Technique —

a Induction with thiopentone

b Maintenance with gas-oxygen-trilene or pethidine

The modern Boyle machine has a luminous back to the flowmeters, and if one hand is kept on the bag of the machine the anæsthetist can be reasonably happy about the condition of the patient while screening is in progress

If there is no luminous back to the flowmeters a small red-glass torch on the machine or the light from the laryngoscope will not interfere with the screening activities and adds to the anæsthetist s peace of mind

Dilatation and Curettage —This is frequently performed under thiopentone alone but there is the likelihood of laryngeal

mixture of 1 g of thiopentone and 120 mg of gallamine triethiodide given in divided doses as required She places a lubricated airway in position and gives added oxygen The thiopentone-gallamine triethiodide mixture produces a still eye, lowers intra ocular tension, and is not conducive to post-operative vomiting

Children's Squints —

a Thiopentone or gas–oxygen–ether induction

b Oral intubation and maintenance on gas–oxygen–ether with an Ayre s T-piece to reduce resistance and oozing The patient must be kept sufficiently deep to keep the eye still and the extra ocular muscles relaxed

VI GYNÆCOLOGY

Hysterectomy, Ovarian Cysts, etc , Myomectomies, Ventro-fixations —

a Induction with thiopentone

b Intubation using a cuffed tube with 50–75 mg of suxamethonium and lignocaine spray

c When the surgeon is ready a small dose of curare (20–25 mg) will usually suffice for the operation with gas and oxygen as the covering agent (1 litre of O to 2 litres of N_2O) Controlled respiration is started using a circle or to and-fro type circuit with the excess gases escaping via the partly open expiratory valve Atropine and neostigmine are usually not required at the end Some anæsthetists prefer to omit the suxamethonium and lignocaine spray and intubate on curare A steep Trendelenburg position is not required with relaxants but it is often difficult to convert the surgeon from what is for some a life-time habit

Cyclopropane can be used as the covering agent, if diathermy is not being employed or gallamine triethiodide as an alternative to curare

d As soon as the peritoneum is sewn up the table can be straightened the soda-lime turned off, and the patient allowed to breathe on her own

Colporrhaphies, Perineorrhaphies, Manchester Operation —Either —

a Induction with thiopentone

c Must not affect the uterus

d Must not affect the fœtus

The best results are probably produced by the use of pethidine in early first stage, followed by volatile narcotics in late first, and during the second, stage

Management of the First Stage —The early part of the first stage of labour can usually be managed by the use of simple sedatives

1 *Chloral Hydrate* gr 20–30 early in labour may be sufficient It is rather irritant to the gastric mucosa, and should be diluted with some flavouring agent

2 *Barbiturates* These are primarily hypnotic and patients in pain are liable to become restless If given in too large doses they may be harmful to the child

a *Nembutal*, gr 3 then gr 1½ in 2–3 hours (max dose gr 7½ in 12 hrs) This may be combined with chloral hydrate gr 20–30

b *Seconal* is shorter acting Give gr 4½, then gr 1½–3 in 4 hours' time (max dose gr 12 in 12 hrs)

3 *Opium Alkaloids* (morphine gr 1/6 or omnopon gr 1/3) if given in the second stage depress the fœtal respiration Hence do not use them within 4 hours of delivery They are of use to prevent exhaustion in a prolonged labour

Twilight sleep A mixture of morphine gr 1/6 and hyoscine gr 1/150 then hyoscine gr 1/400 repeated hourly until the patient became amnesic, was popular at one time It is not a recommended technique as it prolongs labour, produces a restless patient and depresses fœtal respiration

4 *Pethidine* [12] Is probably the most popular drug used to day It has good analgesic and antispasmodic properties, and aids indilatation of the cervix 150 mg can be given intra muscularly early in the first stage of labour and 100 mg 2–3 hours later (maximum dose 400 mg in 24 hours) Vertigo and nausea may occur if large additional doses are given, and occasional cases of pethidine sensitivity occur

Management of the Second Stage —

Inhalation Agents —

1 *Chloroform* mentioned because it is still used by general practitioners in domiciliary practice It is a rapid and effective

spasm as the dilatation of the os is begun The beginner can avoid this pitfall by ensuring that the patient is properly anæsthetized with thiopentone, gas, oxygen, and trilene or ether before the dilatation is commenced

Dilatation and Curettage and Laparotomy—Gynæcologists frequently do not know whether they will proceed with a laparotomy until they have examined the patient under anæsthetic or performed a dilatation and curettage In these cases it is a good plan to intubate with 50–75 mg of suxamethonium and spray the larynx and trachea with 4 per cent lignocaine The dilatation and curettage is done under thiopentone and gas and oxygen with the patient breathing on her own If a laparotomy is required it is then a simple matter to inject the necessary relaxant and carry on with controlled respiration

VII OBSTETRICS

In providing pain relief for childbirth the attitude of the mother is of great importance There are two aspects to the problem 1 Antenatal instruction, 2 Pain relief during labour

1 Antenatal—It is important to explain to the mother the normal process of labour in the antenatal period and what is expected of her Fear of the unknown should be removed, and a decision made on the method of pain relief during labour

She should be told —

a How to work the gas machine if one is to be used

b How to apply the mask and obtain an airtight fit

c The use of the finger hole safety device

d If trilene is to be used the inhaler should be demonstrated and the patient allowed to smell the trilene

e It should be explained that whatever method is used will be under her control so her fullest co operation is necessary for success

f If caudal or spinal analgesia is to be used explain that she will be conscious throughout labour

2 Pain Relief—The drugs used —

a Must produce pain relief and be non toxic

b Must not produce unconsciousness

c Must not affect the uterus

d Must not affect the fœtus

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Twilight sleep A mixture of morphine gr 1/6 and hyoscine gr 1/150 then hyoscine gr 1/400 repeated hourly until the patient became amnesic was popular at one time It is not a recommended technique as it prolongs labour, produces a restless patient and depresses fœtal respiration

4 *Pethidine*[1°] Is probably the most popular drug used to day It has good analgesic and antispasmodic properties, and aids indilatation of the cervix 150 mg can be given intra muscularly early in the first stage of labour and 100 mg 2–3 hours later (maximum dose 400 mg in 24 hours) Vertigo and nausea may occur if large additional doses are given, and occasional cases of pethidine sensitivity occur

Management of the Second Stage —

Inhalation Agents —

1 *Chloroform*, mentioned because it is still used by general practitioners in domiciliary practice It is a rapid and effective

analgesic and is portable and non-inflammable The danger of primary cardiac failure is said to be less in labour, but the danger of delayed poisoning is greater It is toxic to mother and child, and prolongs labour The danger of postpartum hæmorrhage is increased Trilene possesses most of the advantages of chloroform and none of the disadvantages When a satisfactory inhaler is produced, it will no doubt replace chloroform in domiciliary obstetrics

2 *Gas and Air* Usually administered by the *Minnitt*[13] machine (*Fig* 54) which certified midwives are allowed to use *

This machine is an intermittent flow machine, permitting a fixed percentage of 50 N_2O and 50 per cent air to be delivered to the patient It is not as potent as gas and oxygen and there is a longer time lag before the analgesia is effective The patient must start to inhale earlier (60 seconds before the pain) hence the value of good antenatal tuition and the failure of this method with the unco-operative patient This drawback can be overcome by the use of the Chassar-Moir attachment which allows of 3–4 breaths of pure gas before continuing on gas and air If this

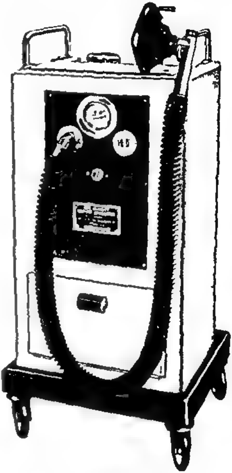


Fig 54—The Minnitt gas and air machine (British Oxygen Gases Ltd)

* *N B* The Midwives Regulations state that this is only after a proper course of instruction and when the patient has been certified by a Medical Practitioner as being fit for a general anæsthetic

attachment is used, however, the machine must not be used by midwives

3 *Gas and Oxygen* Given by the *McKesson* or *Portanæst* machine (*Fig* 55)

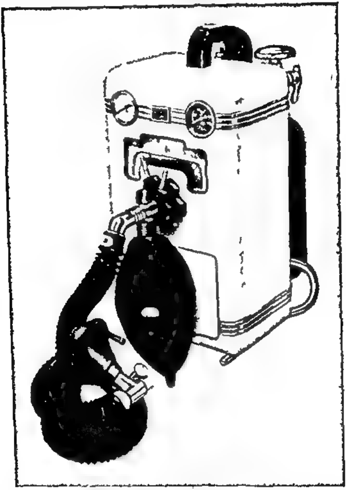


Fig 55 —The Portanæst machine (British Oxygen Gases Ltd)

a Given intermittently to control the pains—15 per cent oxygen and 85 per cent N_2O

b Good analgesia is obtained in 3–4 breaths

c The patient works the machine herself (under supervision)

d She is able to sleep between the pains

e Just before a pain comes on she takes 3 breaths and then bears down

f At the end of the second stage, analgesia can be deepened to anæsthesia by the addition of trilene, ether, etc

g The method tends to shorten rather than prolong labour

h It is contra indicated in heart and lung diseases

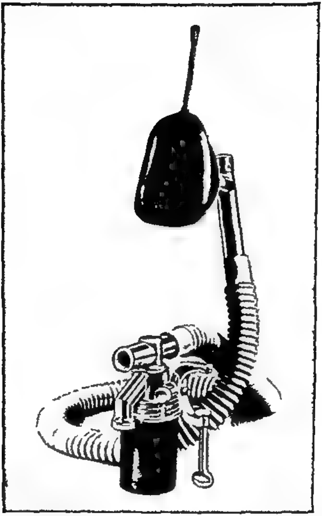


Fig 56—The F dman Inhal (Medic l and Indu trial Equ pment Ltd)

4 *Trilene* Given by inhalers or draw over apparatus The machines in use are the *Freedman*[14] and *Marrett* (*Figs* 56, 57)

a Trilene is a good alternative to gas and oxygen and is non irritant and non inflammable

b The apparatus is easily portable
c It is non-toxic to liver and kidney
d Can be used in heart and lung diseases, and in toxæmia
e There is no tachypnœa at analgesic levels

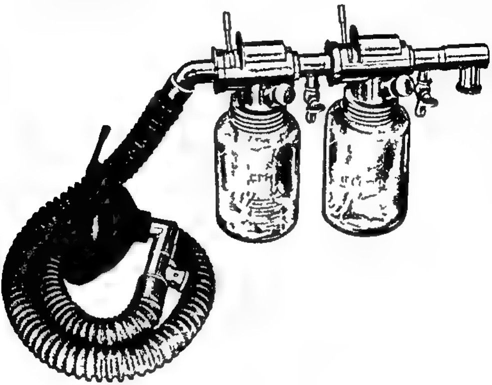


Fig 57—Marrett's trilene apparatus (British Oxygen Gases Ltd)

f The analgesia produced is better than that produced by gas and oxygen, especially if no antenatal tuition has been given

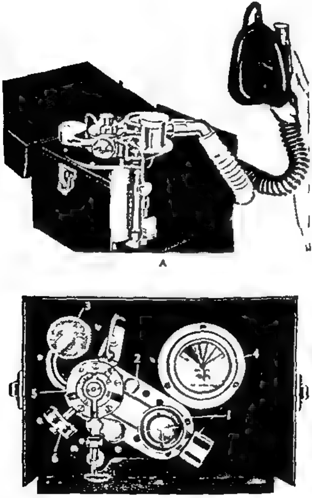
The difficulty with the above types of administration has been to get the concentration of trilene at the 0 5 per cent necessary for analgesia The concentration varies with atmospheric temperature An attempt to compensate for this was made in the *Emotril* inhaler produced at Oxford,[15] which allowed for variable settings depending on the temperature (*Fig* 58)

Recently a method of producing a constant concentration of trilene independent of the temperature, and working on

the Venturi principle, has been tried, apparently with some success.

Local and Regional.—

a *Perineal Repair.*—Local infiltration with 0·5–1 per cent lignocaine.



A

B

Fig. 58.—The Emotril apparatus. (Medical and Industrial Equipment Ltd.)

b *Delivery.*—Infiltrate the pudendal nerves and levatores ani, and supplement with gas and oxygen if required.

c *Caudal.*—Is non-toxic to the child and gives complete pain relief but (1) It is a method which can only be used

in hospital, (ii) A qualified anæsthetic staff is needed to run it

Technique *See under* SPINAL ANALGESIA

Obstetrical Operations —

1 *External Version —*

a Here the technique depends on the needs of the surgeon

b If the surgeon requires a relaxed uterus, induce with thiopentone and proceed to gas oxygen and deep ether

c If the surgeon only requires abdominal relaxation, induce with thiopentone and proceed with gas and oxygen and a small dose of relaxant (*N B* —Relaxants only act on striated skeletal muscle)

2 *Forceps or Delivery* —Premedication gr 1/100 atropine only For forceps delivery *do not* induce with thiopentone, as it depresses the respiratory centre of the fœtus Use gas, oxygen ether or trilene sequence

3 *Cæsarean Section*[16]—The best type of anæsthesia for Cæsarean section is a vexed question, and one on which every anæsthetist has his own views It may best be discussed under four headings (*a*) Local, (*b*) Spinal, (*c*) Caudal, (*d*) General

a Local This is undoubtedly the safest technique for mother and child It is best done by the obstetrician himself, but is time consuming and trying for patient and surgeon

b Spinal A fairly high spinal is required for a painless operation (up to T 8 for lower segment operation), and maternal deaths do occur The reason is that the enlarged uterus splints the diaphragm, and if the spinal paralyses the intercostals at the same time, the mother may die of hypoxia Hence 100 per cent oxygen should be given routinely, and careful blood-pressure readings taken during the operation

Advantages (*a*) No depression of fœtal respiratory centre (*b*) Minimal blood loss

Disadvantages May cause the usual sequelæ of spinal analgesia, e g headaches, persistent paræsthesiæ etc Tonic contraction of uterus

c Caudal (*see also under* "Spinal Analgesia") It has the advantages of a spinal but with little blood pressure fall or

post-operative headache It is more difficult technically, more time-consuming, and less certain in its results

d General

i *Emergency Cæsarean section* Here the great danger is from inhalation of vomit and the poor condition of the child

Technique

α Premedication gr 1/100 atropine only

β Patient towelled up and surgeon ready to start before the induction

γ Suction apparatus ready for mother and baby, and slight Trendelenburg tilt on the table

δ *No thiopentone* or at most, a sleep dose and gas, oxygen, ether or cyclopropane induction

ε Maintain on light ether or cyclopropane until delivery of the baby, then give gr 1/6 morphine or 50 mg pethidine intravenously and deepen the anæsthetic

ii *Elective Cæsarean section* Here again, almost as many techniques are used as there are anæsthetists W D Wylie advises a sleep dose of thiopentone, then cyclopropane and a small subapnœic dose of gallamine triethiodide (40–60 mg) Other anæsthetists decry the use of even small amounts of thiopentone particularly if the baby is premature, and use a gas, oxygen ether sequence throughout

The Use of Relaxants —Most anæsthetists are agreed that *d* tubocurarine chloride passes the placental barrier, at a slower rate than gallamine triethiodide, and on these grounds it is probably wiser to use the former, for Caesarean sections [17] Suxamethonium does not cross the placental barrier and its action, being of such short duration should not affect the babe

VIII GENITO-URINARY

1 Cystoscopy, Retrograde Pyelography, Fulguration of Papillomata —These procedures are usually performed using thiopentone alone (2½ per cent solution for the elderly) If a retrograde pyelogram is required the patient should be awake by the time he reaches the X-ray department He needs to be able to tell the X-ray radiographer when sufficient dye has been injected up the catheter by the feeling of discomfort in the loin Fulguration procedures tend to be

more prolonged, and it is better to maintain with gas-oxygen-trilene, or other non-explosive mixture, than to give too large a dose of thiopentone

2 **Trans-urethral Resection, Trans-urethral Punch** —Many surgeons prefer a low spinal anæsthetic for these operations as it produces more nearly a bloodless field [18]

Technique —Either —

a The patient, sitting up, is lumbar punctured in L 4–5 space and 1 2–1 4 ml of heavy nupercaine injected He remains sitting up for 2–3 min

b He is then placed in the lithotomy position and is put to sleep with thiopentone It is a good plan to give additional oxygen via a nasal catheter or mask A watch should be kept on pulse and blood-pressure throughout

Or *a* Induction with thiopentone

b Maintenance with gas, oxygen, trilene or pethidine

3 **Nephrectomy, Nephrolithotomy, Uretero-lithotomy, Transplantation of the Ureters, Cystectomy, Retropubic Prostatectomy** —The technique is as for gastrectomy, the major procedures being given intravenous plasma or blood as required

Suprapubic Stab or Cystotomy —This procedure is usually carried out on poor-risk patients with a high blood-urea, and therefore done under local analgesia

If a general anæsthetic is required, be very sparing with the intravenous drugs because of the poor kidney function A sleep dose of thiopentone then minimal cyclopropane and oxygen, is probably as good a technique as any, and will provide sufficient relaxation for the performance of the operation

IX THORACIC AND CARDIOVASCULAR[19, 20]

There are several special problems associated with anæsthesia for thoracic surgery —

1 Chronic ill health and toxæmia The patients to be operated on are usually debilitated and cachetic following a long and chronic illness Consequently any flaws in anæsthetic technique result in greater sequelæ and may mean the difference between a successful conclusion and disaster

2 They are operations on the circulatory and pulmonary systems whose proper functioning is necessary for survival

3 Airway control is complicated by secretions, e g, mucus blood, etc

Preparation of the Patient —Adequate preparation of the patient is of paramount importance in these cases, and it is not an exaggeration to say that improvements in this sphere over recent years have revolutionized the outlook

The *principles* are —

1 Building up of the patient s general resistance by bed rest adequate diet vitamins, etc

2 Reduction of the amount of sputum by breathing exercises physiotherapy, postural drainage, and the use of antibiotics By this means the number of really wet lungs ' which now come to operation is almost negligible

The *problems* to be overcome in thoracic anæsthesia are —

1 *Paradoxical Respiration and Mediastinal Flap* —If the patient is allowed to breathe on his own when the chest is opened paradoxical respiration occurs with partial collapse of the good lung Consequently there is a mediastinal shift or flap with each respiratory movement As a result there is diminished oxygen intake, and excess carbon-dioxide retention following the inadequate ventilation This results in a vicious cycle of hyperpnœa and increased mediastinal flap, leading to embarrassment of the cardiovascular system from hypoxia and mechanical causes The solution to these problems is by controlled respiration using a wide-bore endotracheal tube

2 *Sputum Control* —This is dealt with by —

a Adequate pre-operative preparation

b Efficient premedication

c Intermittent suction during operation

d Posture using the prone position [1] (*see* p 124)

e The use of bronchial blockers or endobronchial tubes

3 *Diathermy* —The majority of chest surgeons now prefer to use diathermy for chest operations, to save time and bleeding, so the anæsthetist must use a non inflammable combination of drugs

4 *Resuscitation* —The combination of the poor condition of the patients operated on the length of the operation and the

frequently unavoidable hæmorrhage, makes supportive measures of the utmost importance A good working rule is that the average thoracotomy needs 2–3 pints of blood or its equivalent

TECHNIQUES* [23, 11]

Thoracotomy, Lobectomy, Pneumonectomy, Diaphragmatic Hernia, Œsophagectomy, Transthoracic Gastrectomy—

'DRY' CASES—Ether—

1 Cricothyroid puncture and 2 ml 4 per cent lignocaine instilled into trachea

2 Induction with thiopentone

Or 1 Induction with thiopentone

2 50–75 mg suxamethonium and thorough spraying of cords and trachea with 4 per cent lignocaine

3 Intubation with the largest size cuffed tube which will fit the trachea

4 Maintenance with oxygen-nitrous oxide (40 per cent to 60 per cent in a circle, or to-and-fro circuit with carbon-dioxide absorption) Pethidine can be used as an adjuvant in 10–20-mg doses as required

5 Sufficient curare is given to control respiration[25] Much less is required than for abdominal work 20–25 mg will usually last 40–60 min

Positioning The patient lies on his good side with a supporting strap across the pelvis, the under arm bent comfortably at a right angle and the upper one supported on a rest Sponge-rubber supports for under side and front of chest are an added help

The drip is inserted in the upper arm, as the lower one is liable to suffer some venous congestion

6 A paravertebral block of the intercostal nerves above and below the rib to be resected and a local infiltration along the line of incision, allow the patient to be run at a lighter level of anæsthesia

7 More curare is given according to the feel of the bag, or if the patient commences respiratory movements on his own

8 More pethidine is given if he makes limb movements wrinkles his brow or shows other signs of being too light

9 Atropine and neostigmine are given intravenously at the end if required

Miscellaneous Points—

1 Controlled respiration should be stopped while the surgeon is opening the pleura to avoid puncturing the lung

2 The surgeon should make periodic halts to allow the anæsthetist to blow up deflated parts of the lung

3 When the bronchial stump has been sutured, the cavity is filled with antiseptic fluid and the anæsthetist asked to squeeze the bag to test the integrity of the suture line

4 Once the chest is opened the anæsthetist should so adjust his controlled respiration to keep the mediastinum as near central as possible

5 He should make sure the lungs are fully inflated just before the pleura is closed Prolonged squeezing of the bag with short pauses between will ensure that the atelectatic areas are re-inflated

6 Controlled respiration should be kept up until all muscle layers are closed, and the wound is airtight

7 Often an underwater drain is inserted, and this should swing freely with each squeeze of the bag

8 A watch should be kept on pulse and colour throughout Quite frequently a deterioration in the patient's condition and pulse may be found to be due to the assistant pressing on the vagus nerve with a retractor, and this can be easily remedied

9 Bronchoscopy is usually performed at the end of the operation and the main bronchi sucked clear of secretions This gives an opportunity to inspect the suture line before removal of the bronchoscope It is a wise move to do this before giving the neostigmine and before the patient begins to regain full muscle-tone

'WET' CASES—There are three methods of dealing with these cases, employing (1) Endobronchial blockers, (2) Endobronchial tubes—one lung anæsthesia, (3) The 'prone position

The great danger with 'wet' lung cases is that the secretions from the affected lung which is uppermost in the lateral position, will trickle over the carina and flood the good lung underneath Nosworthy has pointed out that the patient

would need to be at a 35° head-down tilt in the lateral position to avoid this possibility

1 *Blockers*—By the use of endobronchial blockers it is possible to block off the secretions from the affected lung and in this way keep the good lung 'dry' These blockers have a small inflatable cuff at the tip and a lumen down the centre, allowing of continuous suction while they are in position There are two kinds in common use —

The Thompson blocker (*Fig* 59) This is a rather large-sized blocker and the cuff is covered with a nylon net

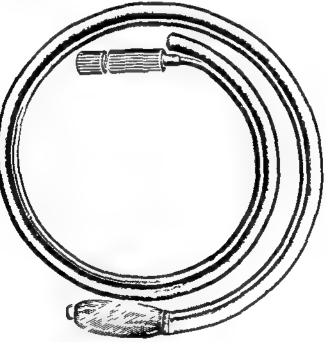


Fig 59—The Thompson blocker (Genito-Urinary Mfg Co Ltd)

It can only be used with the balloon placed in the main bronchus, or distal to the upper lobe bronchus, and requires an 11-mm bronchoscope to pass it

Technique

a The blocker with metal stylet in place is passed through the large bronchoscope until the bulb lies just beyond the beak Then a mark is made on it where the proximal end of the bronchoscope comes

b The bronchoscope is passed (*see under* BRONCHOSCOPY, p 127) The whole secret of successful blocking depends on accurate placing of the bronchoscope, then when the blocker is passed down through it to the mark, the bulb lies just beyond the beak of the instrument

c The cuff is inflated and the bronchoscope carefully removed The cuffed endotracheal tube is then inserted Note that the blocker lies between this and the trachea, and therefore causes a slight leak of gases around it This can be compensated for by increasing the rate of flow of the gases

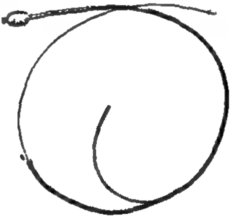


Fig 60—The Magill blocker

Intermittent suction is then applied to the proximal end of the blocker

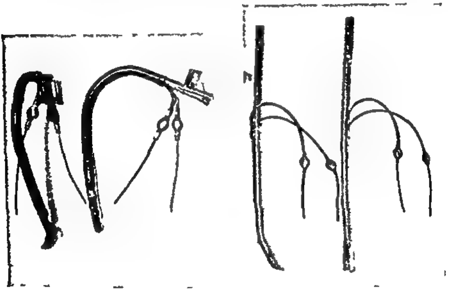
d Once the bronchial stump is clamped (i) the endotracheal cuff is deflated (ii) the blocker cuff is deflated, (iii) the blocker is gently removed aspirating all the while and steadying the endotracheal tube to prevent its removal (iv) the endotracheal cuff is re-inflated and the anæsthetic continued as before

(*N B*—Occasionally the blocker cannot be removed, as it catches on the tip of the endotracheal tube In this case it is better to leave it and remove after the endotracheal tube at the conclusion of the operation)

The Magill blocker (*Fig* 60) This is smaller and the cuff has no nylon net It is therefore easier to put in but tends

to slip out of position It can sometimes be inserted into an upper lobe bronchus

2 *Endobronchial Tubes —The Carlens Catheter*- (Fig 61A) This was first described by Eric Carlens in 1949 and consists of a double lumen cuffed tube which can deliver gases into one or both lungs as required It has a cuff on the left limb and the portion which remains in the trachea has an opening at the entrance of the right bronchus and a rubber hook to sit on



A B

Fig 61 —A Carlens Catheter B Green's Tube

the carina It was originally devised for obtaining broncho-spirometric studies of lung function more easily, but has proved most useful for thoracic anæsthesia The catheter is manufactured in two sizes with diameters of the internal channels being 6 and 7 mm respectively The use of this catheter in thoracic surgery is of value to isolate a clean lung and prevent the spread of secretions and blood, etc from the side being operated on It enables us to inflate or deflate the operative lung while administering anæsthetic gases through the other channel and is therefore particularly useful when looking for bronchial fistulæ which might be hard to detect The introduction of the catheter has caused some difficulties among anæsthetists owing to its shape and the

presence of the carinal hook The first has been overcome by the use of a stylet and the second by using a method recently described by A V Jenkins[78] in the *British Journal of Anæsthesia* This consists of introducing the catheter under full relaxation with the carinal hook facing posteriorly As the tube enters the glottis the hook engages on the posterior commissure preventing further progress The tube is then rotated through 180° so that the carinal hook comes to be directly anterior when it will pass through the intermembraneous part of the glottis into the trachea Finally it is rotated back through 90° so that the tip of the left endo bronchial part of the tube slides down the left side of the trachea into the left main bronchus Not being introduced under direct vision as with a blocker, it is not always easy to be sure that it is correctly positioned Here it is often a help to blow up both cuffs and auscultate one side of the chest while inflating the patient through the corresponding lumen of the tube Useful though this catheter is, it cannot help us in the case requiring a left pneumonectomy which has a marked stenosis of the left main bronchus near the carina or a fistula occurring in a left bronchial stamp In these cases, and for all left lung surgery, a Green s tube is most useful

Green s tube [9] (*Fig* 61B) This consists of a single lumen tube angled at the end to facilitate its entry into the right bronchus It has two cuffs, one to occlude the bronchus and one for the trachea There is a small carinal hook and a slit in the bronchial portion to avoid occlusion of the orifice of the right upper lobe It is introduced with a stylet, the cuffs inflated and its position checked by auscultation of the chest

3 *The Prone Position* —This can be used to provide drainage in bronchiectatic children where blockers cannot be used It can also be used in adult wet ' lung cases as an alternative to blockers but most surgeons prefer to operate in the lateral position

Thoracoplasty —This can be done under general anæs thesia, using a technique similar to that for thoracotomy The patient can be kept fairly light, except towards the end where the pleural stripping is carried out and at this stage he may require extra pethidine or curare

Many thoracic surgeons will only perform the operation under local analgesia, on the grounds that a general anæsthetic may disseminate the infection. A collapsing thoracoplasty following lobectomy is usually done under general anæsthesia.

A satisfactory local technique is as follows [30, 31]:—

FIRST STAGE (After Magill-Semb).—Usually the first two ribs and the posterior half of the third are removed.

Solutions.—(1) 100 ml. 0.5 per cent. lignocaine and 0.5 ml. 1–1000 adrenaline for nerve-blocks.

(2) 200 ml. 0.25 per cent. lignocaine and 0.5 ml. 1–1000 adrenaline for infiltration. This gives the maximum dose of 1 g. lignocaine, and less should be used if possible, especially with the slighter built patient or the debilitated.

Premedication.—Should be heavy. Gr. 1/3 omnopon one hour before, supplemented by a further gr. 1/3 three-quarters of an hour later in fit patients will make endurable what is rather an ordeal even for the most phlegmatic.

Technique.—

1. The patient lies on his back and a brachial plexus block of the affected side is performed by the anterior route (*see under* LOCAL ANÆSTHESIA) using 20 ml. of the 0.5 per cent. solution.

2. The patient turns on his side, affected side uppermost, and he is painted up and sterile towels are draped over him. He should lie with his spine slightly flexed, a small pillow in the loin, and the neck bent forwards. A paravertebral block of the affected side is performed from C 8–T 7, with the 0.5 per cent. solution, 10 ml. in each space. At the same time the back muscles are infiltrated in a fan like manner with 0.25 per cent. solution.

3. The line of the incision is now infiltrated both subcutaneously and intramuscularly with the 0.25 per cent. solution. The incision varies with different surgeons, but generally passes vertically downwards, three fingerbreadths lateral to the spinous processes and then sweeps laterally in a semicircle, three fingerbreadths below the angle of the scapula. It is wise to inquire what incision is to be made before inserting the local. 30–40 ml. of solution placed under the scapula will make its retraction easier.

4 A few ml of 0 25 per cent solution are deposited intradermally and subcutaneously at the four corners, where the towel clips are to be inserted These spots are marked with methyl-violet for the surgeon's convenience

Management —During the operation the anæsthetist watches the patient carefully as regards colour, pulse, etc If the pleura is punctured, the surgeon should repair the defect as soon as possible If paradoxical respiration or mediastinal flap result, the anæsthetist may need to continue with general anæsthesia, and control the respiration The patient usually requires one or two pints of blood during the procedure

SECOND STAGE —This is usually performed a fortnight later and two or three further ribs are removed The surgeon should have divided T 3 nerve at the first stage as it is difficult to infiltrate it, without the landmark of the third rib

Technique —

1 Paravertebral block of T 3–T 8 or T 9 with 0 5 per cent solution

2 Subcutaneous and intramuscular infiltration along the line of the incision with the 0 25 per cent solution

3 Intradermal and subcutaneous infiltration of the four points for towel clips

Bronchography —

Adults —This is performed under local analgesia the technique being the same as for bronchoscopy

Children —This can be one of the most difficult and trying anæsthetics which the anæsthetist is called upon to give These children are frequently poor risk bronchiectatics with a fair amount of sticky viscid sputum This has not infrequently caused a fatality by blocking the endotracheal tube, suction not often being available in the X-ray department

Technique A satisfactory method is as follows —

1 Usual premedication

2 A slow gas, oxygen ether induction (great care being taken to avoid coughing or hypoxic episodes)

3 Spray the cords to prevent spasm

4 Bronchoscope the child and suck out each main bronchus

5 Intubate, using a special bronchogram tube (an endotracheal tube with a side piece to introduce the dye), and use a T piece adapter to allow suction

6 1 ml of 4 per cent lignocaine injected down the endotracheal tube is an added safeguard against coughing

7 Change over to gas, oxygen, and trilene before the radiographs are taken

8 Some radiographers prefer a period of apnœa while the films are being taken This can be obtained by closing the expiratory valve, and by squeezing the bag firmly, stopping the child s respiration for the short time necessary for exposure

9 The opaque medium is injected down the side-tube and the child postured as required

10 At the end of the procedure the opaque medium and any mucus can be sucked out with a gum-elastic suction catheter

Empyema —When an empyema is to be drained it is usually performed under a local analgesic using an intercostal block (*see* LOCAL ANÆSTHESIA) It is done in a sitting position as, if it is performed under a general anæsthetic with the affected side uppermost, and a bronchopleural fistula is present, fluid will flood over to the good lung and drown the patient

If the patient is rather apprehensive and unco-operative, a sleep dose of thiopentone can be given to him in the sitting position Added oxygen should be given at the same time

Bronchoscopy —A good anæsthetist should also be a competent bronchoscopist There are many occasions when the skill will stand him in good stead It is performed routinely in many thoracic cases at the commencement to aspirate secretions, place blockers etc and at the end again, to aspirate secretions and inspect the bronchial suture line

Emergency bronchoscopies are performed in cases of aspiration of vomit or blood, drownings inhalation of foreign bodies, and post-operative atelectases These frequently come within the scope of the anæsthetist, who can, especially if engaged full time be the best qualified person on the spot to cope with the situation The best way to gain experience is to watch the technique as used by the thoracic or ear, nose, and throat surgeons and then practise passing the bronchoscope on the cadaver This will enable one to get the feel of the

4 A few ml of 0 25 per cent solution are deposited intradermally and subcutaneously at the four corners, where the towel clips are to be inserted These spots are marked with methyl-violet for the surgeon's convenience

Management—During the operation the anæsthetist watches the patient carefully as regards colour, pulse, etc If the pleura is punctured, the surgeon should repair the defect as soon as possible If paradoxical respiration or mediastinal flap result, the anæsthetist may need to continue with general anæsthesia, and control the respiration The patient usually requires one or two pints of blood during the procedure

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Technique—

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Bronchography—

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Technique A satisfactory method is as follows —

1 Usual premedication

2 A slow gas oxygen ether induction (great care being taken to avoid coughing or hypoxic episodes)

3 Spray the cords to prevent spasm

4 Bronchoscope the child and suck out each main bronchus

Anæsthesia for Bronchoscopy

Adults —Usually performed under local analgesia

Technique

1 Premedication with gr 1/3 omnopon one hour beforehand

2 The patient sucks two ½ gr amethocaine lozenges half an hour before

Fig 63 —The starting position for introducing the bronchoscope Note (1) The positioning of the patient's head and neck on the special head rest (2) The left thumb and index protecting the gums from pressure by the bronchoscope (3) The grip of the right hand

3 With the patient sitting up and leaning to the left (to ensure that some solution passes down the left bronchus), 2 ml of 4 per cent lignocaine are introduced into the trachea by cricothyroid puncture

4 With the patient still sitting the tongue is held forwards and a small gauze swab soaked in 4 per cent lignocaine is held in each pyriform fossa for 1–2 minutes using a Krause's forceps The patient is then ready for bronchoscopy

Alternative methods are the use of 10 per cent cocaine (max 1 ml) or the use of a Neilson's syringe to introduce the local over the back of the tongue and into the trachea

instrument and recognize the various landmarks From here one can graduate to the anæsthetized patient, and finally to the passing of the bronchoscope under local analgesia

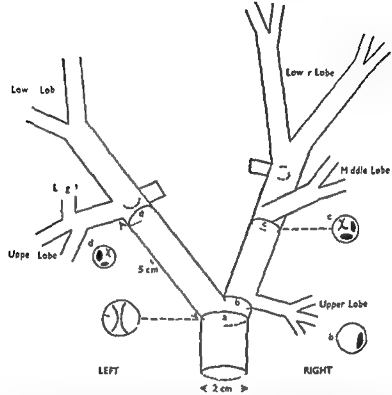

Fig 62.—Diagram of Tracheobronchial Tree a Diagrammatical representation of the view seen through the bronchoscope on looking down the trachea Shows main carina and orifices of right and left main bronchi b Bronchoscope view just beyond the carina in the right bronchus showing the position of the orifice of the right upper lobe c View just beyond the orifice of the right upper bronchus Orifice of right middle lobe at 2 o clock dorsal lobe orifice at 6 o clock and beyond the carina separating the two main bronchi of the lower lobes d View looking down the left main bronchus showing the combined orifice of the left upper and lingular lobes at 9 o clock the orifice of the dorsal lobe at 6 o clock just beyond this and the carina between the bronchi of the two lower lobes straight ahead

Before commencing it is essential to have a sound knowledge of the anatomy of larynx trachea main bronchi and broncho-pulmonary segments It is a help in orientating oneself if the conventional diagram of trachea and bronchi is drawn upside down, the view seen when one is standing at the head of the patient *Fig* 62 shows this and in addition, the position of the various orifices which can be seen through the bronchoscope at different levels

General[32, 33]—The use of a general anæsthetic for bronchoscopies is fraught with difficulties and dangers for the anæsthetist, and sooner or later, if he persists with it, he will strike trouble The recent literature abounds with techniques using thiopentone and relaxants If these do not cause worry during the bronchoscopy, concerning the ventilation of the patient, they usually do at the end, from crowing or laryngospasm Methods of blowing oxygen down a side-tube and blocking the end of the bronchoscope intermittently are most unsatisfactory

If the patient is very nervous or unco operative, probably the best way is to paint him up as for a local, and then give sufficient thiopentone to put him to sleep, adding oxygen down the side-tube of the bronchoscope

Children —Usually require a general

1 Induce with thiopentone or gas–oxygen—ether to relax the cords

2 Spray the cords with 2 per cent lignocaine

3 Maintain on 50 50 gas and oxygen with trilene blown down the side tube

Infants —Induce with open ether to Plane 3, Stage 3 and bronchoscope while the child is emerging from the anæsthetic

Technique of Bronchoscopy

1 The patient is placed in position with his head extended at the occiput and flexed at the neck as for laryngoscopy The bronchoscopy head rest is a great help in these cases (*see Fig* 63)

2 Having checked leads and battery connexions and covered the patient s eyes, the bronchoscope with beak uppermost is introduced into the pharynx at an angle of 90° A gauze swab covers the upper teeth and the anæsthetist s left thumb and forefinger take the weight of the tube from the patient s gums (This is frequently the cause of most worry to the patient during a bronchoscopy) The tube is now passed down the back of the tongue until the epiglottis is seen This is gently lifted forwards and the cords come into view

3 The bronchoscope is now turned through 45° and the beak passed vertically through the cords into the trachea At the same time the patient s head and the bronchoscope are lowered to coincide with normal backward slope of the trachea

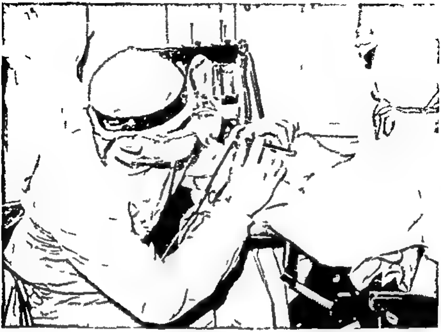

Fig 64 —The bronchoscope in position in the left main bronchus

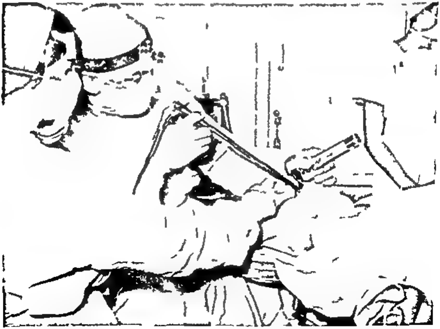

Fig 65 —An alternative method of introducing the bronchoscope in difficult cases Note the use of a Macintosh laryngoscope and an assistant to pull the upper lip out of the way

Technique —

1 Induce with 2½ per cent thiopentone or gas, oxygen, and ether with a high oxygen percentage

2 Spray cords and trachea with 4 per cent lignocaine

3 Intubate, using the largest size of uncuffed tube which will fit comfortably

4 A blood drip is started, preferably in the upper arm

5 2 5–3 mg curare/st body-weight are given and the anæsthetic continued with gas and oxygen, 3 2 Further small doses of curare (one third the initial dose) are required at 30–40 minute intervals Controlled respiration is commenced at a higher rate than for adults (20–25 per minute)

6 The critical point in the operation is just as the ductus is being tied The surgeon usually pulls the ligature tight without tying the knot To an anæsthetist listening with a stethoscope at this stage, there is a dramatic change from the machinery murmur to a normal heart beat The pulse may disappear temporarily, but usually returns within half a minute Should there be other congenital abnormalities present, however, the child will show signs of progressing cardiovascular collapse, and the operation must be abandoned If all is well after three minutes occlusion, the ligature is firmly tied and the chest closed

7 Care is taken that the lungs are fully inflated before the chest is closed and the child returns to bed in an oxygen tent

The successful conclusion of a case of patent ductus arteriosus is a shared triumph for both surgeon and anæsthetist The child is usually sitting out of bed the next day, and returns home in 10–14 days

2 **Coarctation of the Aorta** —This is a congenital narrowing of the aorta, at the site of junction of the ligamentum arteriosum It causes enlarging of the inter costal vessels and collaterals, and consequently notching of the affected ribs There is a hypertension of the upper limbs and a hypotension of the lower limbs This condition should be kept in mind in cases of hypertension occurring in the young

Death is usually due to resulting heart failure, or rupture of the aorta

4 The tube is now advanced down the trachea until the main carina comes into view and it should be noted whether it appears as a normal acute angle, or pathologically widened owing to enlarged hilar nodes, etc

5 *Right Bronchus* To pass the tube down the right bronchus, move the upper end and the patient's head to the left and advance the beak just beyond the carina The orifice of the right upper lobe will be seen at 3 o'clock, ½ cm from the carina, and that of the middle lobe is visible at 12 o'clock, 2 cm farther on The orifice of the dorsal lobe is seen at 6 o'clock just beyond this and straight ahead can be seen the carinæ separating the main bronchi of the basal lobes

6 *Left Bronchus* (*Fig* 64) Similarly the upper end of the bronchoscope and the patient's head are moved to the right and the beak advanced The orifice of the upper and lingula bronchi lies at 9 o'clock about 5 cm from the carina and that of the dorsal lobe at 6 o'clock just beyond this The carinae between the basal bronchi can be seen straight ahead

The position and depth of these orifices must be remembered especially when performing aspiration bronchoscopies, to ensure that all the main bronchi are sucked dry

An alternative method in difficult cases using the Macintosh laryngoscope is shown in *Fig* 65

CARDIOVASCULAR SURGERY[31]

The scope of cardiovascular surgery is increasing rapidly and now includes such conditions as (1) Patent ductus arteriosus (2) Coarctation of the aorta, (3) Pulmonary stenosis and atresia (4) Fallot's tetralogy, (5) Mitral stenosis

1 Patent Ductus Arteriosus—This congenital condition causes a high pulse pressure and a low diastolic pressure leading to enlargement of the heart and ultimate failure due to the left to-right arterial shunt

A second complication is the development of malignant endocarditis which frequently leads to a fatal outcome Surgeons now operate on these cases by passing a ligature around the ductus thereby obliterating it

They should be operated on as soon as diagnosed usually between the first and third years of life

Technique—

1 Induce with 2½ per cent thiopentone or gas, oxygen, and ether with a high oxygen percentage

2 Spray cords and trachea with 4 per cent lignocaine

3 Intubate, using the largest size of uncuffed tube which will fit comfortably

4 A blood drip is started, preferably in the upper arm

5 2 5–3 mg curare/st body-weight are given and the anaesthetic continued with gas and oxygen, 3 2 Further small doses of curare (one-third the initial dose) are required at 30–40-minute intervals Controlled respiration is commenced at a higher rate than for adults (20–25 per minute)

6 The critical point in the operation is just as the ductus is being tied The surgeon usually pulls the ligature tight without tying the knot To an anæsthetist listening with a stethoscope at this stage, there is a dramatic change from the machinery murmur to a normal heart-beat The pulse may disappear temporarily, but usually returns within half a minute Should there be other congenital abnormalities present, however, the child will show signs of progressing cardiovascular collapse, and the operation must be abandoned If all is well after three minutes' occlusion, the ligature is firmly tied and the chest closed

7 Care is taken that the lungs are fully inflated before the chest is closed and the child returns to bed in an oxygen tent

The successful conclusion of a case of patent ductus arteriosus is a shared triumph for both surgeon and anæsthetist The child is usually sitting out of bed the next day, and returns home in 10–14 days

2 **Coarctation of the Aorta**—This is a congenital narrowing of the aorta at the site of junction of the ligamentum arteriosum It causes enlarging of the inter costal vessels and collaterals, and consequently notching of the affected ribs There is a hypertension of the upper limbs and a hypotension of the lower limbs This condition should be kept in mind in cases of hypertension occurring in the young

Death is usually due to resulting heart failure, or rupture of the aorta

The operation consists of excision of the stricture and end to-end anastomosis, or arterial grafting

Anæsthetic Problems —

a There is usually marked bleeding from the chest wall due to the enlarged intercostal vessels, so that blood replacement must be early, rapid, and massive

b As the aorta is clamped preparatory to excising the segment, the blood pressure rises markedly, and falls just as rapidly when the clamps are released Blood must be given quickly at this stage either via the aorta or by two intravenous drips

3 **Pulmonary Stenosis**[35]—This term embraces any stenosis of the outlet of the right ventricle, and is usually subdivided into —

a Stenosis at the outlet, i e, pulmonary atresia

b Stenosis of the pulmonary valve with post stenotic ballooning of the artery

c Infundibular stenosis (beneath the valve and associated with the infundibular chamber)

These patients are not cyanotic, as there is very little shunting of the blood

4 **Fallot's Tetralogy**[36]—This consists of (*a*) Pulmonary stenosis (*b*) Right ventricular hypertrophy (*c*) Interventricular defect (*d*) Over-riding aorta (i e, arising partly from the right ventricle)

The operations performed for these conditions are —

a *Blalock's Operation* which consists of anastomizing the right or left subclavian artery to the pulmonary (an end to side anastomosis)

b *Pott's Operation* where the pulmonary artery is anastomosed to the aorta (side to side anastomosis)

c *Valvulotomy* —This operation has superseded the two previous ones and is now the standard procedure It consists of the passing of a special knife (valvulotome) usually attached to the surgeon's finger with which the valve commissures are split to widen the aperture It may frequently be done by the operator's finger alone In the infundibular type of stenosis, a punch may be used to widen the opening

5 **Mitral Stenosis**[37 38]—This condition is usually the sequel to a previous attack of acute rheumatic endocarditis and

is frequently associated with varying degrees of incompetence of the valve. The latter condition is not amenable to surgery, and it is very difficult to estimate its magnitude pre-operatively.

In these patients there are few contra-indications to operation, except active rheumatic disease. Hence the operation is not usually performed until after 30 years of age, to allow the disease time to burn itself out. There is a slightly higher mortality where there is accompanying auricular fibrillation, owing to the embolic phenomena. These patients are reasonable operative risks, providing hypoxia is watched at all times.

Difficulties.—All mitral stenotics are liable to the following complications:—

a. Heart failure.

b. Pulmonary œdema due to the enlarged pulmonary artery and high pressure within it. Frequently on opening the chest in these cases, the pleural surface of the lung can be seen to 'weep' copiously. The anæsthetist must at all times keep in mind the danger of pulmonary œdema, and remember that all these patients are liable to develop it.

Prophylaxis and Treatment.—Pulmonary œdema may arise from any strain, psychical or physical. Therefore one must:—

i. Sedate well pre-operatively.

ii. Give good premedication to keep the oxygen requirements low, e.g. although usually small and stunted these patients require full adult dose of omnopon gr. 1/3 and scopolamine gr. 1/150 one hour pre-operatively.

iii. Give aminophyllin (α) 250 mg. intramuscularly the evening before; (β) 250 mg. intramuscularly the morning of operation; (γ) 250 mg. with the premedication; (δ) 250–500 mg. intravenously in the acute attack.

The Acute Attack consists of: (i) Orthopnœa; (ii) Crepitations at both lung bases; (iii) Cyanosis; (iv) Imperceptible pulse; (v) Frothy blood stained sputum.

Treatment: (i) Sit the patient up; (ii) Give oxygen; (iii) Venesection; (iv) Aminophyllin.

Anæsthetic Technique.—The whole essence of the technique is to obtain an incident free induction, with no episodes of laryngeal spasm leading to hypoxia.

a Premedication as described

b The patient inhales 100 per cent oxygen for 3–4 minutes

c 2 ml of 4 per cent lignocaine are instilled into the trachea via the cricothyroid membrane

d *Slow* injection of only 0 25 g of thiopentone

e 25–30 mg of curare are injected

f The patient is inflated with oxygen for a further 2 minutes

g A large cuffed tube with suction adapter attached is inserted into the trachea

h Controlled respiration is started with gas and oxygen 2 litres 1 litre/minute, with a carbon-dioxide absorber, and the excess gases are blown out through the expiratory valve

i An intravenous drip of 4 3% dextrose in $\frac{1}{5}$ N saline solution is set up to be changed to blood at a later stage

j *Procaine drip* The vexed question of whether a procaine drip is really necessary for cardiac cases is still undecided The consensus of opinion seems to be that it is of some use in controlling irregularities which occur during operation but should not be used unless there is some definite indication

Method A 1 per cent procaine drip is set up with a size 16–20 needle which can be pushed into the tubing of the blood drip The bottle should be clearly labelled 1 *per cent procaine*, and should be at a higher level than the blood bottle or it will not flow well

The drip is set running, when, and not before the pericardium is opened and the actual manipulation of the heart has begun An average rate of 20–25 drops per minute is usual, the maximum dosage being 1 g /hr or in an emergency, up to 200 mg can be given in 5 minutes

Signs of *overdose* are (i) Dilatation of the pupils , (ii) Fall in blood pressure

The drip should be turned off as soon as the pericardium is closed

Procaine amide is preferred by some anæsthetists in doses of 100–500 mg by intravenous injection Its effect lasts for up to half an hour and it is claimed to be less hypotensive

k *Pacatal* N methyl piperidyl (3) methyl phenothiazine (pacatal) seems to be fairly effective in controlling cardiac

irregularities during manipulation of the heart and pericardium A satisfactory regime is 50 mg with the premedication, then 25–50 mg intravenously at the commencement of the operation and 25–50 mg as the pericardium is opened The heart-rate is slowed and steadied and the post-operative course of the patient is more tranquil

l If there is any residual curarization at the end of the operation atropine and neostigmine are given intravenously, the latter with great care owing to its effect on the heart The aim in these cases should be to produce apnœa by a judicious blending of minimal doses of relaxant, and hyperventilation with CO_2 absorption, so that normal breathing is restored in ½–1 minute after controlled respiration is stopped

m The patient returns to the ward with an oxygen mask applied

Pericardectomy —

Technique —

1 *No thiopentone* for induction, as it is extraordinarily fatal in these cases

2 Cricothyroid puncture with 2 ml of 4 per cent *lignocaine*

3 The patient breathes 100 per cent oxygen for 3–4 minutes

4 Induction with 50 50 gas, oxygen and ether or cyclopropane and oxygen

5 Inject 20–30 mg curare

6 Intubate with large cuffed tube and control respiration

7 Maintain on 50 50 gas and oxygen plus ether or minimal pethidine

8 1 per cent procaine drip is usually required

Angiocardiography[39, 40]—Most children under 12 years of age require a general anæsthetic for this procedure It consists in passing a catheter up one of the forearm veins and into the pulmonary artery under X-ray control Intracardiac pressures are taken as well as samples of blood for gas analysis Finally diodone or some radio opaque material is injected and a rapid series of radiographs taken

Difficulties —

1 These children are usually suffering from congenital heart defects and are cyanotic and undernourished

2 They may be sensitive to the radio opaque dye

3 At the moment of injection of the dye there may be marked bronchospasm, cardiac irregularities, or fall in blood-pressure

4 The technique employed must utilize non explosive agents

Technique—The technique developed by Cope, who has had considerable experience of these cases, is as follows —

1 Premedication with gr 1/100 atropine and rectal thiopentone

2 Induction with 3–5 ml of 5 per cent thiopentone and maintenance with gas oxygen, and minimal trilene, using semi open circuit

3 A small amount of local anæsthetic is injected into the arm before inserting the cannula into the vein

4 Before injection of the dye, the anæsthesia is deepened by injecting 3–5 ml of thiopentone and the child inflated with 100 per cent oxygen

5 When the films have been taken the gas–oxygen–trilene is continued

NEUROSURGICAL

The importance of a smooth, uneventful induction in neurosurgical anæsthesia cannot be over-emphasized especially in intracranial operations Any coughing or straining during this period raises the venous pressure and consequently the intracranial pressure This raised intracranial pressure causes slight coning at the foramen magnum with further venous obstruction, thus starting a vicious cycle The final result is that, on opening the skull herniation of the cortex occurs and may make working conditions impossible After an initial stormy induction it may take 20–30 min for the intracranial pressure to fall to normal Increased resistance in the anæsthetic circuit or head down position on the table will also increase the intracranial pressure

General Technique[41]—

1 *Pre-operative Examination*—It is important to assess the patient's level of consciousness before operation, so as to have a base line to work from The state of the reflexes and any weakness of respiratory muscles should also be noted

2 *Premedication* —In many cases gr 1/100 of atropine half an hour before is all that is required No long-acting opiate should be given, pethidine in small doses is probably the best

3 a *Induction* —In routine cases, induction can be with thiopentone given slowly and in small amounts Where the patient is unconscious, intubation can often be carried out without any anæsthetic, or, at most, a small amount of gas-oxygen-trilene to depress the pharyngeal reflexes

b Intubation[4] —Is routine in most cases The tubes should be armoured to prevent kinking, and of the largest possible bore to reduce resistance Oral tubes are preferable, because of the larger calibre, and no mucus is carried into the trachea from the nasal passages The end of the tube should have a short bevel, and be placed half-way between the cords and the carina, to allow of changes of position of the head during operation The method of intubation may be by crico-thyroid puncture or suxamethonium and lignocaine spray (*see* INTUBATION, p 50) The important point is that the induction should be unhurried, and the anæsthetist should be quite sure, before inserting the tube that the patient will not gag or cough If after the thiopentone and spraying of the trachea there is still some doubt, a few minutes spent giving the patient gas-oxygen-trilene to further depress the pharyngeal reflexes, is well repaid

c Maintenance —Minimal resistance in the circuit is most desirable, so closed circuits are not advisable A semi-closed circuit with a high flow of gases (8 litres of N_2O 4 litres of O_2) with a light expiratory valve or a non-return valve, is suitable Minimal trilene can be added from time to time to prevent the patient objecting to the tube The hardest part for a beginner is learning to keep the patient as light as possible, yet not straining or coughing on the tube One's popularity with the surgeon is short-lived if the latter occurs The aim should be to have the patient awake almost as soon as the tube is removed so that the level of consciousness can be compared with the pre operative level

During the course of the operation, routine blood pressure, pulse, and respiration readings should be taken and charted A blood transfusion is usually commenced after induction, and

the aim is to replace the blood as it is lost, rather than wait for the patient's condition to deteriorate before reviving him There is often a fair blood loss on opening and closing the scalp layers, and the drip should be speeded up at these times

Special Techniques [43]—

Laminectomies, Disk Operations, Spinal Cord Tumours Spinal Fusions —

1 Induction with thiopentone and intubation with a large-bore armoured tube after cricothyroid puncture or suxamethonium and lignocaine spray

2 Maintenance is by gas–oxygen–trilene in semi open circuit

3 The patient is placed in the prone position with pillows under hips and shoulders to allow free chest movement

4 The back muscles in the area to be explored are widely infiltrated with 'lignocaine cocktail' (*see* p 100) This provides a bloodless field, and in most cases will obviate the need for a blood transfusion

Craniotomies —These patients are as a rule poor-risks, and require gentle handling The respiration may be depressed *due to high intracranial pressure, and they may require tapping* of the ventricles first In many cases thiopentone is best avoided and intubation is performed easily after a few minutes on gas–oxygen and trilene The greatest care is needed to avoid errors in technique, hypoxic episodes etc, which may tip the balance unfavourably The technique is the same as for laminectomies and the same care must be taken in choosing, placing, and affixing the endotracheal tube Once the patient is draped and in position it is almost impossible to gain access to the tube Hence for one's own peace of mind it is wise to ensure that no mechanical faults can occur

Section of the Trigeminal Nerve—*This is frequently* performed in the sitting position Care should be taken with thiopentone as the blood-pressure tends to fall more in the vertical position A blood transfusion is not usually required though the basal veins may occasionally be torn during the operation The blood pressure is very labile in this position falling at the start, but rising markedly as the nerve is sectioned

Children —For children s neurosurgical operations, induction with gas–oxygen–ether, intubation, and the use of an Ayre s

T-piece is very satisfactory There are no valves in the circuit, so resistance is minimal [44] Maintenance is with 50 50 nitrous oxide and oxygen, with sufficient ether to prevent objection to the tube If diathermy must be used —

1 Premedicate with avertin 0 1 g /kg
2 Intubate on gas–oxygen–trilene
3 Maintain on gas and oxygen [45 46 47]

Hypotension in Neurosurgery —Many neurosurgical operations, particularly the removal of angiomas, may be impossible without the use of some form of induced hypotension (for details *see* HYPOTENSION, p 205) The resulting fall in blood-pressure—

1 Reduces the formation of C S F
2 Reduces the amount of blood entering the brain
3 Reduces the bulk of the brain

A watch must be kept for cerebral anæmia, often indicated by irregular or deep respiration Extra oxygen should be given to eliminate any possibility of hypoxia, which is badly tolerated in these patients The question of whether to raise the blood-pressure again before the bone-flap is closed is a vexed one If it is raised beforehand, any bleeding vessels can be seen and tied off otherwise a hæmatoma may develop as it rises later

To sum up, the requirements for a good neurosurgical anæsthetic are —

1 A quiet induction and uneventful maintenance
2 Adequate fixation and good positioning of a wide-bore non kinkable endotracheal tube
3 Adequate oxygenation, and elimination of carbon dioxide
4 The avoidance of vasodilator drugs, e g ether etc
5 An even light level of anæsthesia
6 Rapid emergence from the anæsthetic to determine the level of consciousness post operatively

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CHAPTER XI

ANÆSTHESIA IN CHILDREN

THE successful administration of anæsthesia for children is a good test of the ability and personality of the anæsthetist He must be good technically, as there is less margin for mistakes in dosage and administration He must also be prepared to spend time gaining the confidence of the child, and put it at ease if he is to avoid a distressing and stormy induction So much depends on the anæsthetist s manner with children, and it is something which can be cultivated, if he is prepared to put the time and thought into it

Neonatal anæsthesia is almost a sub speciality in its own right Rees in an excellent article, has pointed out that the time has come to consider this problem in relation to the peculiar physiology of the neonate, rather than by adopting methods which have proved to be of value in adults

Anatomical and Physiological Considerations[1 2]—

1 The child has a much higher B M R than the adult and consequently metabolizes the various anæsthetic agents and oxygen at a faster rate

2 The ribs are almost horizontal, hence costal respiration is negligible diaphragmatic being the most important component

3 The lungs are a less efficient organ than in the adult

4 There is a compensatory increase in the respiratory rate (up to 40/min)

5 The infant larynx is relatively higher (the cricoid cartilage is opposite 4C vertebra at birth)

6 The tongue is relatively more bulky

7 The last two factors give a forward angulation to the larynx making intubation more difficult

8 The hyoid is closer to the thyroid which angles the epiglottis backwards at 45° The epiglottis is also more curved from side to side so that a Macintosh laryngoscope is not suitable for intubation

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face without actually touching it For a very nervous child a 'Dolly Varden' bonnet can be made with blanket round its head and the gas led over the edge After a few breaths the mask can be firmly applied and a litre of oxygen/minute introduced The ether is then turned on gradually, and the gas flows altered, until finally the child is maintained on 2 litres of oxygen and 4 litres of nitrous oxide, with as high an ether concentration as may be required

b Gas–oxygen–trilene—The technique is similar, taking care not to introduce the trilene until there is at least 20 per cent oxygen in the mixture This is a useful sequence for many short extra-abdominal procedures in children Only a very small concentration of trilene is required—too much may cause tachypnœa and finally respiratory arrest

3 **Thiopentone Induction**—Thiopentone is quite a useful induction agent for children, its main drawback is that most children fear a needle prick far more than the mask If a $2\frac{1}{2}$ per cent solution is used its administration is not limited so much by the age of the child as by the intravenous dexterity of the operator

In babies the scalp veins may be used 1–5 years, the veins on the volar surface of the wrist, 5 years and over, the antecubital veins

The dosage is 50 mg per stone and it should be given slowly

Maintenance—This may be with nitrous oxide and oxygen with the addition of relaxants if required Children tolerate relaxants well and metabolize them quickly, requiring more frequent repeat doses than adults For relaxation without apnœa give —

a Curare 1 5–2 5 mg /st

b Gallamine triethiodide 10–15 mg /st

Higher doses must be given if controlled respiration is used

Ether has a synergistic action with relaxants and if it is being used the dose should be reduced by half to two-thirds

4 **Closed Circuit**—Closed circuit anæsthesia is not suitable for children except with specially designed apparatus, owing to the dead space and the resistance in the circuit

9 The narrowest part of the larynx is the subglottic region and an endotracheal tube may be held up here if it is too large

Premedication —Heavy premedication obtunds the reflexes post-operatively, and should not be used where early active reflexes are required, e g, tonsillectomies, etc It is justified *a* *Where repeated anæsthetics are required*, *b* *In the hopelessly unco operative child*

The agents used include rectal thiopentone, avertin, or oral barbiturates (*see under* PREMEDICATION) The results are variable, the induction is slowed, and the recovery period is frequently restless

Sheila Anderson[3] recommends rectal thiopentone for children up to 3 st in weight (1 g /50 lb weight) and above this, omnopon and scopolamine according to the following table —

Weight		*Omnopon*		*Scopolamine*	
lb	kg	gr	mg	gr	mg
28	12 6	1/9	7 0	1/450	0 14
42	19 0	1/6	11 0	1/300	0 22
56	25 4	1/4	16 0	1/200	0 32
70	31 6	1/3	21 0	1/150	0 43

Morphine gr 1/40 per stone can be used as an alternative to the omnopon

The advantages are a dry respiratory tract a drowsy child *and analgesia extending into the post operative period*

GENERAL TECHNIQUES[4, 5, 6]

1 **Open Ether** (*see under* ETHER ANÆSTHESIA), usually preceded by ethyl chloride, is still a widely used and satisfactory technique for children With a small mask and a small flow of oxygen beneath it the dead space is reduced and the resistance minimal

2 **Semi-open Circuit** —The Boyle machine can be used on semi open circuit for children over the age of 3 years if a small mask is used to reduce dead space, and the expiratory valve set as loosely as possible to reduce resistance The valve may be propped open with a safety-pin, and the capacity of the rebreathing bag should be reduced, or a smaller one substituted

a *Gas-oxygen-ether* —With a flow of 8–10 litres per minute of nitrous oxide, the mask is gradually brought near the child s

face without actually touching it For a very nervous child a 'Dolly Varden' bonnet can be made with blanket round its head and the gas led over the edge After a few breaths the mask can be firmly applied and a litre of oxygen/minute introduced The ether is then turned on gradually, and the gas flows altered, until finally the child is maintained on 2 litres of oxygen and 4 litres of nitrous oxide, with as high an ether concentration as may be required

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4 **Closed Circuit**—Closed circuit anæsthesia is not suitable for children except with specially designed apparatus, owing to the dead space and the resistance in the circuit

Intubation.—Some cynics have divided anæsthetists into those who can intubate babies, and those who cannot. If the anæsthetist remembers the anatomical differences enumerated at the beginning of the chapter, and is equipped with patience and gentleness, he should have few difficulties.

1. Choose the size of the tube carefully $\left(\frac{\text{Age}+1}{2}\right)$.

2. For neonatal babies and infants, boil the tubes and laryngoscope blade to avoid infection and laryngeal œdema, following any trauma.

3. When intubating under ether, make sure the child is deep enough, and the jaw fully relaxed before attempting to pass the tube. A little 5 per cent lignocaine ointment on the finger tip placed in the glottic opening when the jaw is relaxed often avoids spasm of the cords during intubation or on extubation.

4. If the larynx is angulated more forwards than usual, an assistant pressing on the front of the neck with a finger will correct this.

5. No force should be used at any stage, or the danger of post-operative laryngeal œdema is increased.

6. A straight blade Magill or Shadwell type laryngoscope will be found to be the easiest to use for babies and the small blade of the Macintosh laryngoscope for children.

7. A mixture of thiopentone and suxamethonium can be used as the intubating agent and is recommended by Rees. 100 mg. of suxamethonium is diluted to 10 ml. in a 20 ml. syringe and 10 ml. of 5 per cent thiopentone is then drawn up into the same syringe. The solution must be used immediately or precipitation occurs.

Dose: 2 ml. of the solution per stone. The child is then ventilated until breathing picks up.

Apparatus.—

1. *Renton Orton Absorber* (*Fig.* 66).—This is a circle-type absorber which was designed primarily for thoracic and abdominal work in infants where controlled respiration is used throughout most of the operation, and resistance in the circuit is therefore not important.

It consists of a soda lime canister (A) to which a rubber bag (B) is attached by a short length of corrugated rubber

tubing At the other end are two extremely light flutter valves (C), and two small calibre corrugated rubber tubes (D) leading to the face mask (E) The gases are led-in close to the facepiece via the rubber tubing (F) to reduce the dead space as much as possible Two expiratory valves are provided (G and H) The apparatus can be used for children up to 5 years of age

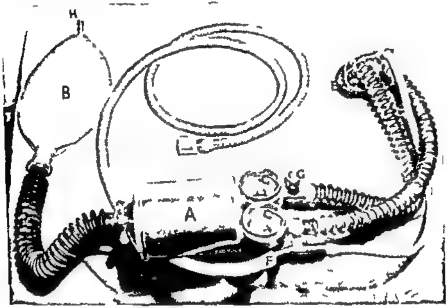

Fig 66 —The Renton Orton absorber (Messrs C I C Ltd)

2 *Cope Absorber* (*Fig* 67) —This is a to and-fro absorber used mainly for cyclopropane anæsthesia in children The canister has a capacity of 200 ml and the dead space is approximately 30–40 ml

3 *Ayre s T-Piece*[7] (*see Fig* 29) —This is a particularly useful piece of apparatus in children, as the dead space is minimal and as there are no valves or soda lime canisters in the circuit, there is minimal resistance

It can be easily and quickly improvised from equipment at hand The amount of rebreathing can be regulated by the length of the side tube (3–6 in), and it can be used for controlled respiration by adding a bag with an expiratory valve to the side tube or by intermittent occlusion of the side tube

Advantages —

1 Minimal oozing

2 Child does not tire easily

3 Dead space is minimal

Disadvantages —

1 It is more difficult to get the child deep, if ether is being administered

2 More extravagant with the anæsthetic agents

Fig 67 —Cope s to nd f o carbon d oxide abso be for infants

SPECIAL TECHNIQUES

Tonsillectomies —

1 *Induction with ethyl chloride* and ether or gas-oxygen-ether to Plane 3 Stage 3

A Boyle Davis gag is then inserted, and the anæsthetic maintained by oxygen and ether from a Shipway (insufflation) or from a Boyle machine The anæsthetist's main worry is then to maintain an adequate airway and a good firm lift of the gag up and towards the head is required The various bipod stands and breast braces rarely seem to maintain an adequate airway for long

The amount of ether given should be judged so that the child has a cough reflex as it leaves the theatre It is put in

the semi-prone 'tonsil' position, with its pelvis on a pillow, to return to the ward (*Fig* 68)

■ *An alternative method* is to intubate with a nasal tube and maintain the child on gas–oxygen–ether It is to be preferred where the surgeon is inexpert, or the operation is expected to take a long time, as there is then no worry concerning the airway

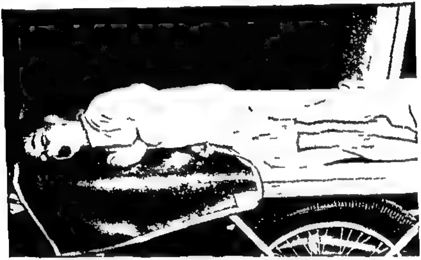

Fig 68 —The s mi prone ■ safe pos tion for return ng unconscious patients to the w d Note the slight h d down t h flexion of the upper leg and airway in position Blood from the pharynx or regurgitation from the stomach will drain out through the mouth instead of entering the trachea

Disadvantages —

■ There is always the possibility of carrying infection, or pieces of adenoid tissue into the trachea on the end of the tube

b There is difficulty in curetting the adenoids with the tube in position If the curetting is left till the end of the operation the child may still be bleeding when he returns to the ward

One solution is to induce the child to Plane 3, Stage 3 with ether, and curette the adenoids while the pharyngeal muscles are well relaxed When the field is dry, a nasal endotracheal tube with a small piece of gauze in its lumen is passed into the trachea by the surgeon The gauze is removed and the dissection of the tonsils carried out under endotracheal anæsthesia

Appendicectomy, Intussusception, etc —May be carried out under open ether or gas–oxygen–ether, with or without intubation In the pyrexial toxic hyperventilating

child who does not tolerate deep ether very well, the addition of small amounts of relaxants will allow the operation to be conducted at a much lighter level of anæsthesia

Mastoidectomy, Squints, etc—The child is intubated and can be run for long periods of time at a light level using an Ayre's T-piece (4 litres of nitrous oxide and 2 litres of oxygen with enough ether to prevent the child objecting to the tube)

Major Abdominal Operations, Thoracic Operations—These cases are treated similarly to adults, using dose for weight of the various agents, e g—

1 Induction with thiopentone 50 mg /st

2 *d* tubocurarine chloride 3 mg /st is then injected or gallamine triethiodide 20 mg /st

3 The largest bore uncuffed tube which will fit comfortably is then inserted into the trachea after spraying the cords with 2 per cent lignocaine

4 The pharynx is carefully packed with ribbon gauze if there is any gas leak

5 50–50 nitrous oxide and oxygen are supplied and controlled respiration instituted at a faster rate than for adults (25–30/minute), using either a Renton Orton unit or a bag attached to an Ayre's T-piece Ether or cyclopropane is frequently used as an adjuvant

6 Supplementary doses (one third the initial dose) of relaxant are usually required at 20–30-min intervals Pethidine may be used as an adjuvant (2 5 mg /st well diluted and given slowly)

NEONATAL ANÆSTHESIA[4]

In the neonatal period (first 28 days) surgery is usually only undertaken for those conditions which are incompatible with life e g —

1 Alimentary Obstructions—

a Atresia of the Œsophagus—There is usually a fistula with the trachea at its upper or lower ends

b Congenital Pyloric Stenosis

c Duodenal Atresia—Usually occurring above or below the bile duct and frequently associated with mongolism

d Atresia of Small Bowel (Often associated with meconium ileus) —A congenital defect of pancreatic secretion (the food is improperly digested and as water is absorbed, the solid bolus obstructs the bowel, giving rise to distension and rupture of the bowel and meconium peritonitis results)

e Septa across the Large Bowel

f Defective Neuromuscular Mechanism —Hirschsprung s disease

g Rectal Septum

2 **Respiratory Obstructions** —

a Bilateral post-choanal atresia

b Micrognathia and enlarged tongue

c Congenital anomalies of the great vessels, compressing the trachea e g , bifid aorta

3 **Miscellaneous** —

a Ectopia vesicæ

b Meningocele, encephalocele, etc

Technique —

Abdominal Cases —The gut fills with gas after birth, and respiration is purely diaphragmatic, so that once the abdomen is opened, the gut tends to protrude We have to diminish this push of the diaphragm and this is done by controlled respiration Muscle tone is not marked in the neonate and therefore relaxants are not of much use It takes only small pressures to bring the child s respiration under control

Neonatal babies are remarkably tolerant of an endotracheal tube, and it is often a good plan to intubate them *before* induction and avoid coughing and the danger of aspiration of stomach contents

Rees,[9] who has had considerable experience with these cases, recommends the following technique —

1 Induction is by leading gases from a continuous flow machine to beneath a Schimmelbusch mask covered with gauze

2 A flow of 2 litres of oxygen for 1 minute then 100 c c of CO_2 then ether to the limit of the patient s tolerance

3 An endotracheal tube is inserted and connected to an Ayre s T-piece

4 The gas flows are now adjusted to 50–50 nitrous oxide and oxygen at 3–4 litres per minute

5 The ether vapour is turned off until limb movements occur

6 The mouth is packed with sterile ribbon gauze and enough ether supplied to prevent limb movements

7 The patient is now placed in position, and a double ended bag applied to the exhaust limb of the Ayre's T-piece

8 When the incision is made, the respiration is brought under control by intermittent positive pressure applied to the bag

9 Anæsthesia is maintained at the lightest possible level, by turning off the ether at 20 min intervals, until limb movements return

Using this technique operations of up to 4 hours have been successfully concluded Alternative methods are the use of the Renton-Orton unit and the use of cyclopropane instead of ether

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CHAPTER XII

GERIATRIC ANÆSTHESIA

With the advance of anæsthetic methods, the scope of surgery is being greatly increased, and it can no longer be said that operations performed on the over-seventies are mainly emergency in nature. As with children, this branch of anæsthesia is a good test of the technical ability and judgement of the anæsthetist.

Small errors in technique or dosage may tip the balance in favour of success or failure. The elderly have a lowered basal metabolic rate, an inelastic cardiovascular system, and somewhat depressed laryngeal reflexes. All these factors must be taken into account before we commence to anæsthetize them. We must avoid episodes of hypoxia or of hypotension, both of which are badly tolerated.

Premedication.—Only small amounts of premedication are required, and scopolamine is best avoided in the over-seventies. Post-operative sedation should also be kept at a low level to avoid respiratory depression and post-operative chest complications.

Anæsthetic Agents.—Ether should be avoided where possible.

Cyclopropane is a useful agent in minimal concentrations, particularly in amputations for gangrene.

Thiopentone in a 2½ per cent solution is a good induction agent if given slowly and in small amounts.

Nitrous oxide-oxygen and minimal trilene is a useful maintenance sequence for extra-abdominal cases.

Suxamethonium.—The value of suxamethonium in geriatric anæsthesia should perhaps be mentioned here. Where relaxation is required suxamethonium is an admirable agent for the aged. It can be given in small doses (25–50 mg.) intermittently, and its effect lasts longer than in the young (5–10 min.). It appears to have no "hang-over" effect and requires no

antidote at the end of the operation It would appear to have a great future in extending the scope of geriatric anæsthesia

Operations —

1 Burst abdomen (*See* EMERGENCY ANÆSTHESIA, p 168)

2 Obstructions (*See* EMERGENCY ANÆSTHESIA, p 165)

3 *Fractures* The commonest fractures occurring in the elderly are Colles' fracture of the upper limb and fracture of the neck of the femur The former may be set using a brachial plexus block or local anæsthetic into the fracture hæmatoma if a general is contra-indicated, for the latter thiopentone, gas-oxygen, and trilene will serve admirably

4 *Prostatic Operations* (*See under* SPECIAL TECHNIQUES, p 117)

Post-operative Care —The elderly are particularly liable to post operative 'chests', as most suffer from some degree of chronic bronchitis This can be effectively dealt with by antibiotics, postural drainage, and inhalations Similarly early post operative ambulation will avoid the danger of pulmonary emboli

CHAPTER XIII

DENTAL ANÆSTHESIA

To give a consistently good dental anæsthetic requires a high degree of skill from the anæsthetist The patients are often unpremedicated and in a highly nervous state There is very little margin, using gas and oxygen, between having the patient grossly hypoxic and jactitating and having him awake and struggling It is a technique which is best learned by watching a *good operator*, *No amount of book reading will replace* actually practising the procedure, and having someone at hand to correct your faults

There are several cardinal principles for success —

1 Spend a few minutes gaining the confidence of the patient and telling him what is expected of him It is well-nigh impossible to give a successful anæsthetic to an unco-operative or frightened patient

2 Establish and maintain nasal breathing Nasal breathing becomes automatic when the patient is at the correct level of anæsthesia As soon as he becomes too light he begins to breathe orally and the anæsthetist loses control of the situation

3 Watch the airway throughout This calls for co-operation and understanding between anæsthetist and dentist, and the latter must be prepared to be guided by the former where the welfare of the patient is concerned

Premedication and Pre-operative Preparation —

1 If the patient is unaccompanied, it is wiser not to give any premedication except gr 1/100 of atropine, if thiopentone or trilene are to be used as adjuvants

2 If the patient is accompanied gr $1\frac{1}{2}$–2 of nembutal or seconal $\frac{3}{4}$ hr beforehand will make the administration of gas and oxygen much easier

3 The patient should have had nothing to eat for 4 hours previously

4 Bladder and rectum should be empty before induction

5 Dentures should be removed, and any tight collars, belts or corsets loosened

Machines —The best type of machine for the administration of a dental gas and oxygen is one of the intermittent flow type Two popular models are —

1 *The McKesson-Nargraf* (*Fig* 69) —The working head of this machine consists of —

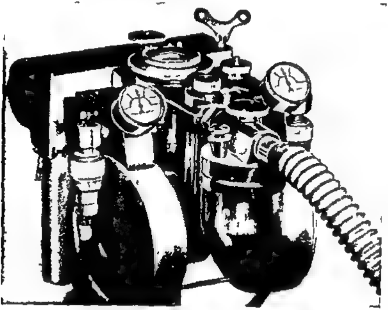

Fig 69 —The McKesson Nargraf head (McKesson Equipment Co (of Gt Britain) Ltd)

A A mixing chamber with

B A vernier scale measuring the oxygen percentage of the mixture

C Two 'cut off' systems which allow gases to enter the chamber during inspiration but cut them off during expiration

D A knob for controlling the pressures at which the gases are delivered

E Emergency oxygen button

F Gauges to show pressure of gases delivered (normal 60 lb /sq in)

G Container for Nargraf bag which allows partial rebreathing Pressure on the bag is altered by a key

The Walton Mark IV (Fig. 70).—This machine also has a 'cut off' system and mixing chamber for the gases. The working panel of the machine shows:—

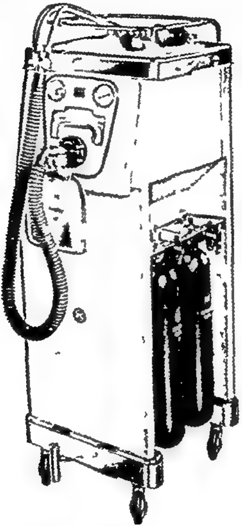

Fig. 70.—The Walton gas oxygen apparatus Model No. IV. (British Oxygen Gases Ltd.)

A. A large dial giving, on one side, percentages of gas and oxygen, and on the other, percentages of gas and air.

B. A large black knob controlling the percentage of the gases.

C. A foot lever to control the pressure at which the gases are delivered.

D Emergency oxygen button
E Dials showing cylinder pressures
F Rebreathing bag

Technique —

The McKesson Machine —The technique is as follows —

1 Sit the patient comfortably in the chair with a loose waist strap which can be tightened later if required

2 Adjust the head rest so that the head is in the 'sniffing the air position

3 Inquire as to previous history of cardiac or respiratory disease and place a stethoscope bell on the apex beat to re assure the patient if not yourself!

4 Explain what is required of the patient—'to close the eyes relax and breathe regularly in and out through the nose

5 If the patient is co operative, insert a dental prop before induction When the patient is very nervous it is easier to establish nasal respiration with the mouth closed, inserting a prop after induction, using a mouth gag if necessary

6 Check the machine to see that the gas pressures are within the normal working range Set the oxygen percentage at 5 and the gas pressures at 10–15 mm Hg so that a good flow is obtained

7 Adjust the expiratory valve on the nose piece to a light setting

8 Hold the nasal mask ½–1 in in front of the patient s nose and gradually lower it on to his face (this avoids a feeling of asphyxia)

9 As the patient loses consciousness, place the rubber mouth piece or a gamgee swab over the mouth to encourage nasal breathing Wait until the patient is properly anæs thetized *i e* —

a Regular breathing
b A tinge of cyanosis
c Loss of tone in orbicularis oculis
d No eyelash reflex
e Deflexion of the eyeballs

10 Then, and then only proceed to insert the mouth pack making sure that it gives a comparatively airtight barrier

behind the operative field, yet not so far back as to obstruct the airway or touch the pharynx, causing the patient to gag

11 The oxygen percentage is gradually increased until a maintenance level of 7–10 per cent is reached The longer the operation, the higher the percentage of oxygen should be

12 Watch for *signs of lightening*, e g —

a Prolongation of expiration,

b Phonation or gagging,

c Limb movements,

or *signs of being too deep*—

a Increasing cyanosis,

b Jactitations

If the patient becomes too light or starts mouth breathing, ask the dentist to stop cover the mouth, and reduce the oxygen percentage until surgical anæsthesia is re-established

13 At the conclusion of the operation, remove the nose-piece, sit the patient forwards, so that the blood does not trickle down the pharynx, and allow him to come round quietly of his own accord

The Walton Mark IV —The technique is —

1 Set the dial at 100 per cent nitrous oxide

2 Adjust the foot lever to ' medium flow '

3 Proceed as before, gradually increasing the oxygen percentage to a maintenance level of 7–10 per cent when the patient is anæsthetized

Position (*Fig* 71) —

1 The anæsthetist stands behind the dental chair his fore-arms resting comfortably on the chair back the left hand supporting the angle of the patient s jaw, the right supporting the nose piece

2 *Nasal Airway* When difficulty is met with in establishing a nasal airway a small lubricated nasopharyngeal airway, inserted in one nostril will help

3 The anæsthetist can help the dentist considerably by applying counter pressure as required supporting the mandible for lower teeth and pressing down on the vertex for upper extractions

D Emergency oxygen button

E Dials showing cylinder pressures

F Rebreathing bag

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3 The anæsthetist can help the dentist considerably by applying counter-pressure as required supporting the mandible for lower teeth and pressing down on the vertex for upper extractions

4 *'Collapse'* When a patient 'collapses' during a dental anæsthesia, the cause is most frequently hypoxia. Treatment is to insert a nasopharyngeal airway, close the expiratory valve on the nose-piece, and give 100 per cent oxygen intermittently under pressure, if necessary laying the patient flat to do so

Fig 71 —Shows patient positioned for dental anæsthesia with prop in position The left hand supports the angle of the jaw

5 *Adjuvants* [1, 2] In robust males or prolonged extractions it is better to use an adjuvant with the gas and oxygen rather than subject the patient to marked hypoxia for any length of time There are two good alternatives —

a 0 2–0 25 g of thiopentone given intravenously at the commencement allows a higher percentage of oxygen to be used The patient should be accompanied home afterwards

b Minimal amounts of trilene added to the gas and oxygen will help in difficult cases The oxygen percentage should not be held below 15–20 per cent while it is being used

6 *Full extractions* or removal of difficult wisdom teeth are better performed under endotracheal anæsthesia using a naso tracheal tube and carefully packing off the pharynx The patient should be admitted overnight

DENTAL ANÆSTHESIA IN CHILDREN

Children over 6–7 years can be managed successfully on gas and oxygen, though there is less margin to work on between having them awake and struggling or cyanotic and jactitating

Below this age, there are several alternatives —

1 Ethyl chloride with the child in a semi-reclining position is very satisfactory for single extractions[3, 4]

Fig 72 —Goldman's vinesthene inhaler

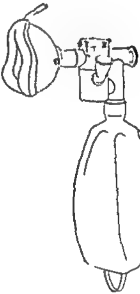

Fig 73 —The Oxford vinesthene inhaler

2 A few breaths of gas followed by divinyl ether in a Goldman or Oxford inhaler (2 ml for under 5 years, 3 ml for 5-year olds) (*Figs* 72, 73)

3 Gas–oxygen–trilene is satisfactory for longer cases The trilene vapour must be minimal as it is easy to get respiratory or cardiac arrest in children with too high a concentration[5]

Amnalgesia —Tom[6] has recently reported on a new technique for dental gases particularly applicable to children It consists of producing the condition of amnalgesia , which has been described by Klock as a plane of surgical anæsthesia between the so called analgesic plane and the second or excitement stage wherein surgical operations may be performed without pain or memory The technique is new in that it postulates using a high percentage of oxygen (15–20 per cent) with the nitrous oxide

The patient starts with 5–6 breaths of pure N_2O and the oxygen percentage is raised to 15–20 per cent The pressure must be adequate but not too powerful, nasal breathing must be maintained and the nosepiece must be a good fit The eyeball should be either rolling or fixed in a conjugate deviation and it should appear expressionless It is a rather difficult technique to master, but has the following advantages

1 There is no hypoxia
2 Operating conditions are smoother
3 Gagging and swallowing reflexes are not abolished

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CHAPTER XIV

EMERGENCY ANÆSTHESIA AND RESUSCITATION

ANÆSTHESIA for emergency cases is a rather neglected branch of the specialty A large proportion of the cases occur at night, and consequently they are left to the more junior resident members to cope with They are usually poor-risk cases and it is remarkable that the mortality and morbidity figures are not higher than they are Morton and Wylie, in a review of anæsthetic deaths found that no less than 24 per cent were due to aspiration of vomit Inadequate post operative care or resuscitation accounted for another 10 per cent Unless we can interest the more senior members of the profession in this aspect of anæsthesia, and instil an appreciation of the dangers of these cases into the more junior members, it will be difficult to reduce these figures

FACTORS TO BE CONSIDERED

1 **The Full Stomach** —The importance of ascertaining the presence of food or fluid in the stomach before operation and dealing with its presence *effectively* cannot be too strongly emphasized The Ryle s tube was originally designed to take gastric samples only, and was never meant to empty a stomach of food It is useful in that it is easily introduced, and on aspiration will give an idea of the stomach contents indicating whether a washout with a full sized stomach tube is necessary The mechanism of death from vomiting may be —

a Massive obstruction of the airway (by food bolus etc)

b Anoxia due to the obstruction

c Reflex inhibition of the heart by vagal stimulation from the epiglottis or carinal area

d Late effects—lung abscesses etc

Prevention.—The patients can be divided into three classes (Morton and Wylie[1, 2]):—

i. *Food or fluid is known to be present in the stomach*.—

Treatment:—

(*a*) The stomach must be emptied before induction by washing out with a stomach tube or (*b*) the operation must be postponed.

ii. *The presence of food or fluid is suspected though there is no recent intake*. E.g., after accident cases, where gastric stasis may have occurred.

Treatment: A Ryle's tube is passed, and aspiration will give some indication of whether it is necessary to pass a stomach tube, and wash out the stomach.

iii. *There is no reason to suspect food in the stomach*. Here no precautions are necessary.

(*N.B.*—Remember that the important time period is between the last meal and the accident, not between the accident and the arrival at hospital. Children may have a gastric stasis of 8–10 hours following an accident.)

Once vomiting has occurred.—

a. Put the patient in the Trendelenburg position.

b. Suck out the pharynx and insert a pharyngeal airway.

c. *Oxygenate* the patient before carrying out further toilet.

d. Intubate and suck out trachea and bronchi as required.

e. Bronchoscopy is not usually required, unless a solid particle of food has been inhaled.

Do not forget that the stomach and pharynx require aspiration at the end of the anæsthetic also and before the endotracheal tube is removed. Particularly where relaxants have been used there is often a silent regurgitation of stomach, and even duodenal contents into the pharynx awaiting aspiration into the trachea.

2. **Shock**.—Accident cases frequently arrive exhibiting the classical features of shock, viz.:—

a. Pale, cold, clammy and sweating.

b. Hypotensive with a thin thready pulse.

c. Immobile and apathetic.

d. Cyanotic.

Treatment—

1 Warmth, but not overheating of the patient

2 Intravenous morphine or pethidine (*N B*—If given subcutaneously, in the presence of a sluggish peripheral circulation, it may not be absorbed till much later)

3 Trendelenburg position, to maintain cerebral circulation

4 Intravenous plasma or blood as required

5 Added oxygen where the patient is cyanotic

When is the patient fit for an anæsthetic?—Unless the hypotension is due to bleeding, which can only be controlled by operation, it is a good working rule to have the blood-pressure at 100 mm Hg systolic for half an hour before the induction If this is not possible, it is permissible to proceed, providing that active resuscitation measures are carried out at the same time as the anæsthetic is given

Agents to use in shock—

1 Thiopentone is useful, if used with discretion Shocked patients require remarkably little and it should be used in a 2½ per cent solution, 1 ml at a time

2 Cyclopropane in minimal concentration is a good agent, as a high oxygen percentage can be used with it

3 Gas and oxygen 50 50, with or without a trace of trilene, is often sufficient for many extra abdominal cases

4 Relaxants can be used as required The main point to remember is to keep a good oxygen percentage in the mixture, and use the minimum amount of narcotic drugs

TECHNIQUES

1 Intestinal Obstruction—This offers one of the most difficult challenges to the anæsthetist, for the following reasons

a The patient is ill he is usually debilitated elderly, dehydrated, and with his body electrolytes upset The obstruction is often due to a carcinoma, with its concomitant cachexia and toxic absorption

b All the dangers of aspiration or regurgitation of stomach and intestinal contents are present

c Because the abdomen is usually grossly distended, the surgeon requires every ounce of additional relaxation the anæsthetist can give him

d Where the cause of the obstruction is obscure, the patient may need to be almost eviscerated for long periods of time

e Full relaxation is required right to the end, to enable the abdomen to be closed

It is therefore not surprising that articles appear regularly in anæsthetic journals on the best method of anæsthetizing these patients, a sure sign that the best method has yet to be found The use of the curare-like relaxants in these patients is fraught with anxiety They appear to have a very prolonged effect, and much smaller doses are required Foldes[3] and others have noted prolonged respiratory depression with gallamine triethiodide in debilitated, dehydrated patients with evidence of potassium deficiency They noted that the infusion of a 0 3 per cent potassium chloride drip at the rate of 100–120 drops per minute hastened the return of normal respiration

Recently the following technique has been tried with some success in these cases Particular attention to the details described is necessary for the safety of the patients, but the results would seem to justify the extra trouble required —

Technique —

a Premedication is atropine gr 1/100 half an hour preoperatively

b The patient comes to theatre with an intravenous drip and Ryle s, or stomach, tube in position

c The patient is placed on the operating table in the *anti-Trendelenburg* position and the Ryle s tube aspirated This positioning is to prevent any further regurgitation from the stomach after a thorough aspiration

d A suxamethonium drip is set up (1000 mg in 500 c c of Bart s solution) and the needle pierces the rubber tubing of the original drip close to the vein

(*N B* —It is necessary to have the suxamethonium bottle 6 in higher than the bottle of saline or blood in order for it to run freely The control knob should be firmly fixed to the upright of the drip stand, so that the flow rate can be altered with one hand)

e An assistant induces anæsthesia with 0 25–0 4 g of thiopentone and follows this with 50–75 mg of suxamethonium from another syringe

f While he is doing this, the anaesthetist stands waiting at the head end of the patient, with laryngoscope and cuffed tube ready to intubate as soon as the suxamethonium twitches have ceased. No time is wasted on inflating the patient with oxygen, the important point being to insert the tube, blow up the cuff, and so protect the tracheobronchial tree from any aspirated contents.

g The patient is now started on a controlled respiration with N_2O and O_2 in the proportion of [illegible] : 1, using a semi-closed circuit and soda lime absorber.

h The drip is not started until the patient shows by a diaphragmatic flicker that the effect of the original dose is wearing off. This gives an indication of the sensitivity of that particular patient to suxamethonium.

i The drip rate is adjusted to provide optimum operating conditions for the surgeon, turning it off every 10–15 minutes until diaphragmatic flicker returns. By this means administration of an overdose can be avoided.

j The drip is turned off when the peritoneum is closed, and the patient will be breathing strongly as the last skin stitch is inserted.

k Most of these poor-risk cases require no further analgesia, but if the patient shows signs of reacting 15–20 mg. of pethidine intravenously will settle him.

l Both stomach and pharynx are thoroughly aspirated before the cuffed tube is removed.

An alternative and more orthodox technique is :—

a The patient is placed in the *Trendelenburg* position.

b Induction with gas–oxygen–ether, or cyclopropane, after aspiration of stomach contents.

(*N.B.*—It is important to remember that the laryngeal reflex in these patients is markedly reduced and it is usually sufficient to put them to sleep in order to be able to intubate them.)

c Once a cuffed tube is inserted small amounts of relaxants can be given as required.

d The same care is required at the end of the operation, to aspirate both stomach and pharynx, before removal of the cuffed tube.

In this method, reliance is placed on the fact that even if the patient vomits during induction, he still has some laryngeal reflex present, and the Trendelenburg position will prevent aspiration of stomach contents while the pharynx is being sucked out

2 **Burst Abdomen, Perforated Ulcer, Strangulated Hernia** —These may also be anæsthetized satisfactorily using either of the above techniques

3 **Ludwig's Angina** —Wherever there is any œdema of the floor of the mouth, or the tissues of the neck associated with dyspnœa, the anæsthetist should beware of inducing the patient before intubation As soon as the patient has been induced the tension of the tissues surrounding the glottis relaxes, allowing the œdema fluid to track downwards and complete the respiratory obstruction The patient usually has associated trismus, making the introduction of an oral tube impossible

Technique —

a The nasal fossæ on one side are sprayed with 4 per cent lignocaine

b A small-bore nasal tube is gradually introduced spraying down its lumen with a Macintosh syringe as it is advanced

c When it is judged to have its distal end just above the glottis, the patient is instructed to take a deep breath and it is quickly pushed into the trachea

d Once intubated the patient is then induced with thiopentone as soon as possible and the operation commenced

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CHAPTER XV

ANÆSTHETIC EMERGENCIES AND DIFFICULTIES

1 **Cough**—This occurs frequently after induction with thiopentone and during the change-over to ether, the latter being irritant to the tracheobronchial tree It is usually due to too little thiopentone being given before the change-over, or too rapid an increase in the concentration of ether A little carbon-dioxide in the mixture before the change over will often speed the induction, and a slightly higher concentration of nitrous oxide in the mixture to begin with will depress the laryngeal reflexes and make the patient more tolerant of the ether concentration

2 **Respiratory Obstruction**—This may be due to —

a *Nasal Obstruction*—Polypi, etc

b *Lips or Tongue*—Especially in edentulous patients These are corrected by the use of a pharyngeal or nasopharyngeal airway

c *Laryngospasm*—This may be due to (i) Administration of thiopentone (ii) Reflex stimulation from the operative field (iii) Direct stimulation of the cords or epiglottis by foreign bodies blood, saliva, or vomit

The treatment is to eliminate the cause, i e deepen the anæsthetic if it is a reflex effect, or remove the source of irritation if it is a direct effect If the patient is becoming deeply cyanosed as a result of the laryngospasm, the primary aim is to keep him oxygenated if necessary by giving 50 mg of suxamethonium intravenously and inflating with oxygen

3 **Bronchospasm**—

Causes—

a Reflex stimulation during too light anæsthesia

b Histamine release from *d* tubocurarine chloride

c An irritant in the tracheobronchial tree, e g bile stomach contents

d An endotracheal tube impingeing on the carina

f The administration of thiopentone or cyclopropane in an asthmatic

Treatment.—Removal of the trigger mechanism, e g —

a Deepening the anæsthetic

b Using gallamine triethiodide instead of *d* tubocurarine chloride

c Removal of irritant secretions in the tracheobronchial tree

d Removal of the tube from impingeing on the carina

e Care in giving thiopentone or cyclopropane to asthmatics

f 0 25 g of aminophyllin intravenously, 8–10 minims of 1/1000 adrenaline subcutaneously, or the incorporation of ether in the mixture, will relieve an established bronchospasm

4 **Apnœa**.—There are several types of apnœa encountered during anæsthesia and it is important to be able to differentiate these in order to institute the correct treatment

Apnœa may occur during induction or maintenance of the anæsthetic

a *During Induction*.—The probable cause is reflex breath holding due to an irritant vapour e g , ether, the patient being insufficiently anæsthetized or objecting to the presence of an endotracheal tube

Treatment.—Remove the irritant vapour temporarily or deepen the anæsthetic with intravenous thiopentone

b *During Maintenance*.—Apnœa occurring during maintenance should be taken to mean overdosage of some anæsthetic agent until proved otherwise

Treatment.—Stop the anæsthetic and ventilate the patient with oxygen until breathing is adequate, or until the appropriate antidote has been given

c *Post operative Apnœa and Respiratory Insufficiency*.—The problem of apnœa or inadequate respiration persisting after the conclusion of an anæsthetic is one which is exercising the minds of anæsthetists to a considerable extent at the moment There are several causes for the phenomenon and the complete answer has not been fully worked out as yet

d *Causes for persisting Apnœa*.—

i Overdose of relaxant or sensitivity to the relaxant used

ii Overdose of narcotic

iii Acarbia

iv Hypercarbia

Treatment The treatment consists in diagnosing the cause of the apnœa (often the most difficult part) and applying the appropriate remedy

Relaxants —It is sometimes difficult to decide, after a curare-like relaxant has been given (followed by an adequate dose of neostigmine) whether a persisting apnœa is not due to reflex breath holding from the presence of an endotracheal tube If the patient responds to movement of the tube in the trachea by contracting the recti, removal of the tube will often start him breathing again (2 ml of nikethamide intravenously will sometimes trigger off the respiratory mechanism at this stage)

Narcotics —If it is thought that a factor in prolonging the apnœa may be an overdose of narcotic the appropriate analeptic drug can be given

Acarbia —This factor is usually eliminated by turning off the soda-lime some time before the end of the operation

Hypercarbia —If through underventilation or faulty soda lime the patient accumulates carbon dioxide during the anæsthetic this may cause a persisting apnœa It can be diagnosed by taking a sample of blood for analysis and the treatment is to hyperventilate the patient through fresh soda lime

Suxamethonium Apnœa [1]—There are two theories as to the cause of apnœa persisting after the administration of suxamethonium

a The patients are usually debilitated poor-risk cases thought to be deficient in pseudo cholinesterase, which consequently fails to break down the suxamethonium An infusion of fresh blood is worth trying in these cases

b Where the total dose of suxamethonium is large i e, in a long operation, some of the suxamethonium is thought to be broken down to the monocholine and produces a dual action The monocholine acts as a competition inhibitor and its effect can be reversed by neostigmine For this reason it is probably unwise to use continuous suxamethonium as a relaxant in operations which will take more than 1½–2 hours

Neostigmine Resistant Curarization.—Hunter[2] recently reported 6 cases of poor-risk patients who exhibited persisting apnœa or inadequate respiratory movements post operatively following the administration of curare-like drugs. They all died from cardiovascular collapse despite adequate ventilation. He was unable to give a reasonable explanation for the fatalities, and to judge from the volume of correspondence following the article,[3] the complete answer has yet to be found. The low potassium level exhibited by some of these patients may have been a factor. Burchell[4] states that there is need for further investigation into this type of reaction. He suggests:—

a. Blood chemistry, especially potassium levels.

b. Serum cholinesterase and choline levels.

c. The reaction of muscles to the stimulation of nerve trunks which would differentiate between central and peripheral depression.

Treatment. Until the aetiology is established, treatment is difficult but the following principles apply:—

a. Where the serum potassium is low, avoid using competition inhibitor relaxants.

b. Where the serum cholinesterase is low, avoid using suxamethonium.

c. If controlled respiration is used, employ a negative phase in the circuit.

d. Often these very poor risk patients can be intubated and the operation completed using a minimal amount of inhalational anæsthetic (e.g. cyclopropane and oxygen) omitting the use of relaxants.

5. **Primary Cardiac Failure**.[5, 6]—

This catastrophe can be detected by:—

a. The appearance of cyanosis associated with pallor especially on the extremities of the patient.

b. The disappearance of the pulses (especially the carotid).

c. The cessation of respiration if this is not being controlled.

It is important to have a plan of action mapped out, and the following is a specimen scheme which can be modified for local conditions.

PROGRAMME OF ACTION—CARDIAC RESUSCITATION

Anæsthetist —

1 *Notify surgeon immediately* pulse and blood-pressure disappear—*do not waste time*

2 *Instruct nurse* to get cardiac-resuscitation trolley

3 *Deliver 100 per cent oxygen* immediately

4 *Ask surgeon to check pulses*—aorta, heart, carotid or other major artery

5 *Endotracheal intubation*—tracheobronchial aspiration

6 *Keep time from onset*—notify surgeon when 3 minutes have elapsed

Surgeon —

1 *Open chest immediately*—anterior thoracotomy in 4th left intercostal space

Commence cardiac massage—squeeze heart vigorously, preferably between two hands at rate of 40–60 per minute Carotid pulse should now be palpable B P 60–70 mm Hg

It is preferable to open pericardium avoiding phrenic nerve

2 *Trendelenburg position*—5–10°

3 *Cardiac standstill* ten times as common as ventricular fibrillation

a If no response after 5 minutes massage give 3–5 ml of 1 10 000 adrenaline into left ventricle and continue massage

b If no response and heart still flaccid, give 3–5 ml of 10 per cent calcium chloride Massage

c If necessary cardiac massage for 1 hour or preferably for 2 hours

4 *Ventricular Fibrillation* (The heart is writhing in diastole) If no response after 5 minutes' adequate massage, use defibrillator Pericardium must be opened and electrodes covered and moistened with saline are placed firmly against ventricles One shock is given for 0 1 sec at 140 volts If not successful repeat shocks before moving to higher voltage

If asystole or weak contraction after defibrillation give 3–5 ml calcium chloride 10 per cent solution into left ventricle (this is to tone up the cardiac muscle), or 3–5 ml of 1 10 000 solution adrenaline

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CHAPTER XVI

POST-OPERATIVE CARE COMPLICATIONS AND TREATMENT

AT the conclusion of an anæsthetic, the patient's pharynx should be sucked clear of accumulated secretions, a pharyngeal airway inserted, and paraffin drops instilled into the eyes if the operation has been at all prolonged He is placed on a trolley in the semi prone position so that if he should vomit on the way back to the ward, it will not be aspirated into the trachea The anæsthetist watches the patient s airway until he has handed him over to a responsible ward nurse who is trained in the care of the unconscious patient As soon as he is conscious the patient is gradually sat up on pillows and encouraged to cough

RESPIRATORY COMPLICATIONS[1 2 3]

The incidence of post-operative respiratory complications depends on several factors —

1 *The Presence of Pre existing Respiratory Infection* —This increases the liability, and it is unwise to operate until the chest condition is cleared up, or minimized Chronic bronchitics are particularly prone to develop atelectases post-operatively

2 *Sepsis* —The percentage of complications is increased in the presence of infection, e g , peritonitis etc

3 *Site of Operation* —Over 10 per cent of cases follow abdominal section, especially upper abdominal cases

4 *Sex* —Men are more likely to suffer post-operative respiratory complications probably owing to the higher incidence of smoking

5 *Type of Anæsthesia* —This appears to be immaterial A high percentage follows local analgesia probably owing to the poorer-risk patients involved

The types of complication encountered are —

5 Intravenous fluids and blood are given during cardiac massage and after restoration of heart-beat

6 Close observation in operating room following cardiac massage

7 Transfer to a respirator if breathing is not resumed after restoration of heart-beat

8 *Cerebral Œdema*—Prophylactic treatment for cerebral œdema is commenced if the heart-beat has not started in 3–4 minutes Intravenous injection of 100 ml triple strength plasma or 50 per cent sucrose solution and repeat 4-hourly

Ten ml of intravenous procaine solution 1 per cent are given once or twice a day to relieve cerebral vasoconstriction

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2 'Tickling' the epiglottis with a gum elastic catheter to produce the same effect

3 Finally, if the area still remains collapsed, bronchoscopy is performed under local anæsthesia, and the mucus plug sucked out

3 **Pneumonias** —Broncho or lobar pneumonia may occur post operatively It can be differentiated from atelectasis by the following points —

a The onset is slower, 3–7 days

b The temperature is higher 103–104°

c There are gross physical signs in one lung without displacement of the apex beat

d The patient is much more toxic

Treatment —Antibiotics, etc

4 **Pulmonary Infarct and Embolism** —

Symptoms —

a Onset 10–20 days

b Depending on the size of the embolic fragment the symptoms may vary from a sharp pain in the side accompanied by blood-stained sputum, to collapse with dyspnœa, cyanosis, and death

Treatment —Anticoagulant therapy

5 **Lung Abscess** —Usually follows aspiration of infected material, vomitus, etc

Symptoms —

a Delayed onset, 2–3 weeks

b Minimal physical findings

c Severe toxæmia—foul breath and sputum

Treatment —Surgical Massive doses of antibiotics

6 **Empyema or Subphrenic Abscess** —The presence of an empyema or subphrenic abscess post operatively is often overlooked When suspected its presence can be demonstrated by X rays or an aspirating needle

Treatment —Surgical drainage

ALIMENTARY COMPLICATIONS

1 **Vomiting** —The incidence of post-operative vomiting varies from 40–50 per cent when using ether and cyclopropane

1 Bronchitis —

Symptoms —Slight cough and rise in temperature, with some moist sounds usually at the lung bases

Treatment —Expectorants, encouraging the patient to cough, and antibiotics if required

2 Atelectasis —There appears to be a higher incidence of atelectasis following the introduction of relaxants Whether this is due to the fact that some patients are returned to the ward still partly curarized, or whether it is because we are more on the look-out for atelectases these days, is hard to say

Symptoms —

a Sudden onset of pain in the chest after 24–36 hours, accompanied by a slight temperature rise

b Dyspnœa and cyanosis, if the atelectatic area is massive enough

c There may be displacement of the apex beat to the affected side

d Lessened movement and dullness on percussion over the affected area

e Radiograph shows an area of collapse

Cause —The cause is usually a plug of mucus obstructing a bronchus, with absorption of the air distal to it and consequent collapse of the affected segment

Treatment —The regime recommended by Palmer and Sellick gives very satisfactory results In the high-risk patient e g chronic bronchitics it is started 7–10 days pre operatively and carried on post operatively

It consists of —

1 Oral inhalation of 1 ml of 1 per cent isoprenaline t d s

2 15–20 minutes of postural drainage with the foot of the bed raised 18 in Clapping and vibratory percussion to the chest (the basal areas during expiration) This is carried out in the two lateral and the prone positions (5–10 minutes each)

3 Procaine penicillin 600,000 u b d (*N B* —Cardiac cases contra indicate the use of isoprenaline)

If this regime fails to prevent a collapse, the following methods are tried —

1 The injection of 2 ml of paraldehyde or 2 ml of nikethamide intravenously to make the patient cough

the nerves during operation, the applications of tourniquets, etc

Treatment—This is, of course, prophylactic Watch the position of the limbs, and the padding of the operating table,[5] and correct any faults, at the time

BURNS

Diathermy burns may occur from the patient's arm being in contact with a goitre screen, etc It should be part of the anæsthetist's duties to see that no areas are in contact with the metal part of the table When the patient returns to bed, care should be taken that no uncovered hot-water bottle is in contact with his skin

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to 15–20 per cent with agents such as thiopentone and gas and oxygen

Treatment —

a Ensure that, by correct positioning of the patient no vomit is inhaled

b If persistent, some of the anti-histamine drugs, e g, promethazine hydrochloride intramuscularly, will often settle the patient Many patients are nauseated with morphine, and merely stopping the post-operative injections will settle them

2 **Gastric Dilatation and Ileus** —Occasionally a patient will continue vomiting persistently, and is found to have developed an acute gastric dilatation or an ileus of the small intestine

Cause — This is often obscure —

a It may be a sympathetic imbalance peculiar to the patient

b The parasympathetic action of neostigmine has been blamed

c Hexamethonium is known to cause ileus on occasions

d It often follows excessive handling of the bowel by the surgeon or it may be paralytic, following a peritonitis

Treatment —

a Gastric or duodenal suction

b Intravenous replacement therapy

URINARY COMPLICATIONS

Many patients have difficulty passing water post operatively, especially —

a If they are of a nervous disposition

b After spinal anæsthetics

c After rectal or genito urinary operations

Treatment —

1 Psychological re assurance, privacy running taps etc

2 One ml of carbamyl choline chloride intramuscularly

3 If all else fails aseptic catheterization

NEUROLOGICAL COMPLICATIONS

1 **Headaches** —(*See under* SPINAL ANÆSTHESIA, p 183)

2 **Nerve Palsies** —Various nerve palsies e g, brachial sciatic, ulnar, etc can result from pressure or stretching of

6 Palpate the spinous process above and below, and raise a skin bleb of local anæsthetic between the two

7 Introduce the spinal needle at right angles to the skin at this point, until the characteristic 'give', as it pierces ligamentum flavum and dura, is felt

8 Advance a further ¼ in and remove the stylet

9 If bony pedicle is encountered aim the point of the needle higher or lower

10 *a* The appearance of clear C S F at the hub of the needle indicates a successful puncture

b Pure blood dripping slowly usually indicates a vertebral vein has been punctured

c The so called 'dry tap' may be due to (i) A blocked needle (ii) Failure to enter the subarachnoid space (iii) Piercing the posterior septum

Spinal Analgesics—

Low Spinal, using hyperbaric solutions —

1 *Heavy Nupercaine* (1/200) The effect lasts 3 hours Perform lumbar puncture as before Introduce 0 6–1 ml in L 4–5 space Lie the patient down after one minute No Trendelenburg position for 15–20 minutes, or the solution will travel up the subarachnoid space

2 *Procaine* Lasts 1–1½ hours Introduce 100 mg (1 ml of 10 per cent diluted with 1 ml of C S F) in L 4–5 space in the sitting position Lie the patient down after 2–3 minutes

Mid Spinal (*up to T 7–8 level*) —

1 *Heavy Nupercaine* Inject 1 6–1 8 ml in L 3–4 space and place the patient in 5° of Trendelenburg

2 *Procaine* Inject 150 mg diluted with 4 ml of C S F in L 3–4 space and place the patient in 10° Trendelenburg These heavy spinal solutions are recommended because they are thought to be more controllable than the light The practical factors controlling the spread of the solution are —

a The degree of propulsion with which the solution is injected

b The specific gravity of the solution

c The posture of the patient

CHAPTER XVII

SPINAL ANALGESIA

THE position of spinal analgesia[1] has undergone considerable regression in the last few years. The reasons are:—

1. The introduction of relaxants, which produce operating conditions equal to those of spinal analgesia.

2. The threat to anæsthetists of litigation, which may result from accidents occurring during, or after, the administration of spinals. The position at the moment is that the anæsthetist must be prepared to justify his use of a spinal anæsthetic in a Court of Law if necessary. Consequently the main operation still performed by most surgeons under a low spinal is that *of trans-urethral resection of the prostate.* For this reason, the technique for low and mid spinal analgesia only will be described.

Technique for Lumbar Puncture.—

1. All ampoules, needles, and instruments to be used should be dry autoclaved at 20 lb. pressure for half an hour.

2. The anæsthetist scrubs up, and dons sterile gown, mask, cap, and gloves.

3. The patient sits on the side of the trolley or operating table with his back fully flexed, elbows resting comfortably on his knees, and supported by a nurse. An alternative position is to have the patient lying on his side with the back fully flexed. Care should be taken in this position to have shoulders and hips in the same plane, to avoid rotation of the spine. In fat patients the median line sags downwards, and allowance must be made for this.

4. The back is draped with sterile towels, and the area as far round as one iliac crest is painted with some coloured antiseptic.

5. The iliac crest is palpated, and a horizontal line from here gives the level between L. 4 and 5 vertebræ.

Contra-indications —

1 Where the blood-volume is greatly reduced, e g, in dehydration, hæmorrhage, etc, because of the loss of compensatory mechanisms

2 The presence of myocardial ischæmia, i e, angina or history of coronary occlusion

3 Use with care in anæmias, owing to the reduced capacity to carry oxygen i e if the hæmoglobin is below 40 per cent

4 Emphysematous patients

5 Raised intracranial pressure

Partial Contra-indications —

1 Extensive lung disease (use a high oxygen percentage)

2 Gross abdominal distension—tumours, pregnancy, etc

3 Previous neurological disease (for medico legal reasons)

Complications and their Treatment —

1 Syncope, nausea vomiting, and sweating These can be avoided by anæsthetizing the patient

2 Puncture of a nerve root can be avoided by performing the lumbar puncture in the midline

3 Breaking of the needle

4 Fall in blood-pressure Give methyl amphetamine 10–15 mg intravenously

5 Respiratory depression Give oxygen and assist respiration if necessary

Post-operative —

6 Chest complications are no more frequent than with general anæsthesia

7 Retention of urine Treated by the use of carbamylcholine chloride or by catheterization

8 *Headache* Occurs in 18–20 per cent of cases [3]

Causes —

a Sitting up too soon afterwards

b Poor technique in lumbar puncture causing seepage of C S F The use of too large a spinal needle

c Pre-operative dehydration resulting in post operative fall in C S F pressure

d The use of an irritant drug e g stovaine

Treatment Keeping the head low correcting dehydration and the administration of codeine, pethidine, etc

Physiological Effects of Spinal Analgesia —

1 Paralysis of motor, sensory, and sympathetic roots

2 The susceptibility to procaine varies the autonomic fibres being more sensitive, the autonomic block is often 3-4 segments higher than the sensory

3 *Respiratory* — The intercostal muscles are progressively knocked out as the level of the solution ascends The degree varies with the extent of the muscular paralysis, and the ability of the remaining muscles to compensate for the loss Normally this is very effective, i e, when the intercostal and abdominal muscles are paralysed the diaphragm can still carry on Trouble can arise however, when there is some interference with the action of the diaphragm e g, in ileus, abdominal tumours pregnancy, etc

4 *Circulation* —The effect on circulation depends on the number of autonomic fibres blocked A fall in blood-pressure indicates a failure in compensation, and may occur suddenly The fall in blood-pressure which occurs occasionally with a low spinal may be due to some of the spinal solution entering the blood stream, and exerting a direct effect on the vasomotor centre

5 *Alimentary System* —Movement and tone are increased, the bowel is constricted and the sphincters are relaxed

Miscellaneous Points —

1 In the majority of cases it is wise to first anæsthetize the patient who is to have a spinal performed

Reasons —

a For the patient s sake

b 25 per cent of conscious patients are nauseated or vomit during a spinal This does not occur under general anæsthetic

2 For anything higher than a low spinal, a high concentration of oxygen should be given to avoid the dangers of hypoxia

Advantages —

1 *Good muscular relaxation*

2 Reduced hæmorrhage

3 It protects the patient from neurogenic shock and he is in better shape after major surgery, e g, abdominoperineal resection

4 There is no post-operative pain or restlessness

CHAPTER XVIII

LOCAL ANALGESIA*

It is essential to realize that *the management of the patient* is all important Knowledge of the mode of action preparation sterilization dosage and technique of the local analgesic drugs administered is essential, but must take second place [1]

It is possible to provide, by means of local analgesia, sufficient pain relief to allow the performance of almost any operation Rarely, the poor state of a patient makes this mandatory without regard to other matters Normally the frequency with which local analgesia is the chosen method is dependent essentially on the confidence and familiarity of the anæsthetist and surgeon, with satisfactory techniques of patient management

Patient management covers the anæsthetist's and the surgeon's approach to the patient what is or is not said and how, the attitude of nursing and other staff ward handling, completion of all possible preparations before premedication is given and rest in quiet surroundings to allow optimal drug action Quiet gentle handling and avoidance of noise from that point on supplementation of premedication intravenously in the anæsthetic room or theatre, necessary reassurance, avoidance of unnecessary gossip or attraction of the patient's attention and much else is an essential part of the technique The art depends basically on an ability to assess and understand each patient as an individual person and to go quietly along with him Secondarily it depends on a judicious choice of premedication drugs and proper timing of administration

The Corlette table of morphine–hyoscine premedication with the exceptions and precautions given by the author is satisfactory

In brief total dosage is decreased in the very small, the very sick and whenever anoxia is feared—e g, anæmia, heart

* This chapter has been written by Mr S de C Barclay Surgeon Grey Hospital New Zealand

Permanent neurological damage may occasionally occur Two cases occurred in 1947, where the ampoules of spinal anæsthetic had been stored in phenol, and a crack had developed in the ampoule, allowing contamination of the spinal solution [4] Because of these rare catastrophes, spinal analgesia should only be used where specially indicated

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2 Bacterial filtration (with rigid care of technique) Chemical additives are unreliable and give a false sense of security Once a container of solution is unsealed in any way it *must* forthwith be used or discarded

Toxic Reactions —These are much rarer in the premedicated patient Emotional reactions may be confused with and mistaken for them in the unpremedicated patient Though emotional reactions are then commoner, so also are true minor toxic reactions Premedicate always, except for minor cases

Reaction Signs —

Minor Pallor, sweating tachycardia sense of oppression, excitement

Major Gross tachypnœa convulsions, respiratory, and central nervous system depression

Prevention —Toxic reactions usually follow the use of unnecessarily strong solutions intended to be precisely placed in small amounts The average technique is imprecise enough to make these methods unreliable and the anæsthetist tends to use more solution without decreasing the strength Avoid toxic reactions by using weak solutions copiously (Absorption of a small volume of a strong solution is faster than of a large volume of a weak one) Use vasoconstrictors with the solution reducing the quantity (e g , from 1/200,000 adrenaline to 1/400 000 or less) in hypertension and thyrotoxicosis Avoid in general, the use of hyaluronidase preparations

Treatment —

1 Administer a small dose of thiopentone followed by a relaxant

2 Intubation

3 Oxygen controlled or assisted respiration

Maximum Safe Dosage —(Do not become obsessed by these figures Cultivate the habit of using weak solutions so that you never approach a dose level that will give concern)

Toxicity weight for weight lessens as dilution increases

For a healthy male of 70 kilos —*Permissible volume of solution*

Procaine	1 0 g	200 ml of ½ per cent solution
	0 75 g	75 ml of 1 ,, ,
	0 5 g	25 ml of 2 ,, , ,,

failure, or respiratory embarrassment Hyoscine alone is decreased in thyrotoxicosis Supplementation with intravenous pethidine is frequently desirable The alert, slightly fuddled, or restless patient will usually pass rapidly and pleasantly to sleep Dosage, 20–100 mg

If sleep is profound, see that the head is supported or turned to keep a good airway Give oxygen by nasal catheters (5 litres/minute) if cyanosis or deep sleep causes concern (This concern is usually needless in my experience) If it is desirable to rouse the patient before return to the ward, 2–4 ml nikethamide is given intravenously

With experience one's fear of these heavy premedication doses disappears The beginner with local analgesia is better advised *to have too much premedication than too little*

Mode of Drug Action —Theories are —

1 Lipoid solubility (Meyer-Overton)

2 Ionic dissociation—intracellular formation of an active cation from dissociation of absorbed base

The mechanical pressure of solution in the tissues aids diffusion into tissues and cells to some extent

The solution should be neutral and rendered isotonic by the appropriate addition of sodium chloride

Sterilization —(*Table I*)

1 Boiling or autoclaving

Table I

AGENTS USED IN REGIONAL ANALGESIA WHICH CAN BE RE STERILIZED BY AUTOCLAVING*

Drug	*Temperature*	*Time*	*Max No of Re sterilizations recommended*
Heavy nupercaine	120 C	20 min	1
Ephedrine hydrochloride	120 C	20 min	2
Lignocaine hydrochloride (without epinephrine)	120 C	30 min	Can be repeatedly sterilized

AGENTS WHICH CANNOT BE RE STERILIZED BY AUTOCLAVING

Procaine hydrochloride (solution and crystals)
Epinephrine hydrochloride
Amethocaine hydrochloride
Lignocaine hydrochloride with epinephrine hydrochloride

* *A M A Fundamentals of Anesthesia* 1954 p 268 Philadelphia W B Saunders Co

3 *Nupercaine* (Cinchocaine B P)—Of occasional value, to give longer acting analgesia either alone in strength 1/2000 or 1/3000 with procaine or lignocaine Maximum dose in such use 0 1 g in 300 ml of solution with adrenaline 1/200,000

4 *Cocaine*, *Amethocaine*, *Eucaine*[1] *Proctocaine*[5]—Are examples of drugs and compounds having now no acceptable place in any form of local analgesic technique All have dangers, and none are more advantageous than Lignocaine

Syringes and Needles—For minor injections any suitable syringe will suffice Needles should be as fine as possible The barrel capacity should not exceed 10 ml or injection is a strain on the hand, unless needlessly big needles (with added danger of vascular puncture) are used, and barrel fracture (and cut hand) are more likely

Labat s 10 ml syringe with finger grips and set of graduated needles is preferred by some It is rather more clumsy than Pitkin s self-filling syringe[6] (5 ml barrel) which is preferable where large amounts are to be injected This syringe requires careful attention to assembly, screwing all parts, particularly the metal plunger, *firmly* together Leakages and dissatisfaction usually arise from faulty assembly Rarely a valve sticks This trouble is immediately recognizable (by the free emptying of the syringe on withdrawal of plunger with the nozzle occluded) and rapidly remedied (unscrew valve housing prick valve with needle end, lift out, and wipe and gently replace) Test aspiration requires pinching of the rubber supply tubing best done by a nurse or assistant

Needles—Recommended —(1) 24 gauge 1 in —all skin punctures, intercostal blocks in thin patients finger blocks, etc (2) 22 gauge 2 in –4 in —general purpose (3) 22 gauge 6 in —splanchnic block, (4) 20 gauge 8 in —large infiltrations away from major vessels etc

Infiltration—This is of universal application and the technique of infiltration should be followed in all areas reducing needle point to a small range in so called nerve-blocks

1 Raise a *small* intradermal weal warning the patient of the prickle

2 Infiltrate subcutaneous and muscular layers injecting the fluid ahead of the needle as it is advanced

For a healthy male of 70 kilos —*Permissible volume of solution*	
Lignocaine	400 ml of ¼ per cent solution
Max dose, 0 8–1 g	150 ml of ½ ,,
	50 ml of 1 ,, ,,
	25 ml of 2 ,, ,,
	5 ml of 4 ,, ,,

(2 per cent and 4 per cent—Topical use only)

Vasoconstrictors —Adrenaline 1/200,000 is satisfactory Greater strength is unnecessary and undesirable except perhaps in some special (e g , dental) work Toxic adrenaline reactions can occur, but are rare and insignificant if the maximum dose is 1 ml (adrenaline 1/1000) in 200 ml of solution Dilution affects absorption rate and toxicity of adrenaline as it does the analgesic

Hyaluronidase [2]—Should not be used in ordinary practice, but may be of value in special circumstances, e g , therapeutic injection of painful ligaments joints etc Normally its disadvantages offset any advantages It is better to abandon techniques which attempt wide diffusion of small amounts of strong solution, and instead use larger amounts of a weak solution

Drugs —

1 *Procaine* —Soluble in water and alcohol and is one quarter as toxic as cocaine The effect lasts from 45–90 minutes It is used in strengths of 0 25–1 per cent for infiltration and 1–2 per cent for nerve blocks

2 *Lignocaine Hydrochloride* (Xylocaine) [3]—Synthetic Swedish origin Solution may be repeatedly boiled without loss of efficacy Effective quickly duration varies from 1½ hours (¼ per cent with adrenaline 1/200 000) to 2½ hours (1 per cent with adrenaline 1/200 000)

Recommended strengths 0 25 per cent for infiltration 0 5–1 per cent for true nerve-blocks 2 per cent for topical analgesia of serous surfaces (peritoneum and pleura)—maximum dose 25 ml —and preferably in jelly, urethra 4 per cent for topical analgesia of skin, squamous covered surfaces surfaces covered by mucus saliva etc (nose mouth larynx, carina, vagina) Lignocaine seems destined to dominate the field of local analgesic drugs

SOME USEFUL REGIONAL BLOCKS

1 **Maxillary V Nerve —**

a Identify the angle between the mandible and the lower edge of the zygoma (in front of the coronoid process)

b Insert a fine needle to hit the tuberosity of the maxilla then slide the point around behind it by raising the hub of the needle

c Push the needle in no more than $1\frac{1}{2}$ in and inject 3–4 ml of 1 per cent lignocaine after aspiration

2 **Mandibular V Nerve —**

a The patient is asked to open his mouth, when the condyle of the jaw slips forward and can be palpated with a finger

b Leaving the finger in position, the patient closes his mouth the finger now indicating the position of the sigmoid notch

c Insert a fine needle through the notch till it strikes the pterygoid plate

d Work the point backwards to the posterior edge of the plate and inject 1–2 ml of 1 per cent lignocaine, after aspiration (*N B* —If the needle goes too far it may pierce (i) Eustachian tube (ii) pharynx)

This block will anæsthetize mandible, tongue, and temporal region on the corresponding side, and is useful for taking a biopsy of the mouth etc

3 **Inferior Dental Block —**

a Start with the needle at the lateral incisor of the opposite side

b Pass it horizontally inwards on a plane with the buccal surface of the teeth

c Feel the anterior edge of the ramus with the thumb of the opposite hand

d Insert the point of the needle for half the width of the ramus and deposit 1–2 ml of 1 per cent lignocaine after aspiration

4 **Brachial Plexus Block —**

Supraclavicular —

a The patient lies supine, with his head on a low pillow and turned to the opposite side

b The affected shoulder is depressed as much as possible

3 If the needle point is kept moving during injection the chances of injecting any great quantity of solution into a vein are negligible

4 All layers should be infiltrated in a fan-like manner

5 Keep a watch on the total amount of anæsthetic injected, but if you find this restricts your freedom, use a weaker solution next time

Methods —

1 *Diffuse infiltration* of the operation field is almost always applicable and gives a field convenient for the surgeon to work in *Contra indicated* in cancer or surgery of sepsis

2 *Field block* An infiltration of all layers at a distance from the area May be a complete encirclement or a single wall interrupting the nerve-supply The field of operation is undistorted and this method may be used where diffuse infiltration cannot be A variant of this is circumferential limb block where all the tissues surrounding the bone or bones are freely infiltrated with weak solution forming a cuff around the limb Satisfactory for all work including amputations, below upper thigh and upper arm providing that in amputation major nerve-trunks are injected with stronger solution when first exposed Bleeding is greatly reduced

3 *Nerve block* A small quantity of solution is deposited in or very near to a nerve trunk at a strategic point Commonly and simply seen in mid axillary intercostal nerve blocking which supplemented by infiltration of the incision area provides good relaxation and analgesia for abdominal surgery The lower five or six intercostal nerves are blocked by inserting a fine needle beneath the rib keeping low in the interspace and injecting 5–8 ml of ½ per cent lignocaine at a depth of ¼ in –½ in deep to the rib margin keeping the needle slightly in motion Test aspiration is unnecessary for this block if a fine (22–24 gauge) needle is used and the point kept moving For other blocks in areas of greater vascularity test-aspiration is necessary Always aspirate gently as well as forcibly lest a vein wall has collapsed over the point In these precision blocks small volumes of stronger solution may be used and will give longer lasting analgesia

Warnings —

1 Adrenaline should never be added to the solutions for ring blocks owing to the vasoconstriction leading to gangrene of the digit

2 Ring blocks should not be performed for septic conditions of the fingers for the same reason

3 Do not infiltrate so much solution as to compress the blood supply to the digits

7 **Paravertebral Block** —There are not many occasions when paravertebral block has any advantage over more peripheral blocks It may, however, be of value in therapeutic testing, and possibly in treatment of lower limb conditions

a Thoracic —In order to determine which nerves one is blocking, it is necessary to have a fixed landmark, which is usually the spine of the T 12 vertebra To locate this follow the last rib up at 45° until it meets the vertebræ Drop a perpendicular in the midline for 5 cm and this will indicate the spine of T 12 vertebra

Technique —

i Raise intradermal weals one and a half fingerbreadths lateral to the midline and opposite the lower borders of the spines

ii Pass a fine 5 cm needle at right angles to the skin through these weals until bone is encountered This should be the transverse process of the vertebra

iii Withdraw the needle 1 cm and direct the point upwards slightly, to pass over the upper border of transverse process Insert the needle for 1 cm only beyond the upper border of transverse process

iv Aspirate, then inject 8–10 ml of 1 per cent lignocaine, moving the point of the needle about slightly as this is done

v Repeat for the required number of spaces

Hazards —

i Puncture of the pleura can be detected by aspiration of air

ii Puncture of the theca Prolongations of theca may accompany the spinal nerves through the intervertebral foramina If local analgesic is injected a spinal analgesia will result so (α) Keep away from the midline, and (β) Aspirate for C S F first

c The supraclavicular area is cleaned with spirit and sterile drapes applied

d A skin weal is raised $\frac{1}{3}$ in above the mid-point of the clavicle

e Hook a forefinger over the clavicle, and palpate the subclavian artery If it can be felt, the block is simple, as the plexus lies immediately dorsolateral to the artery

f If no artery is palpable, introduce a fine spinal needle downwards backwards, and inwards towards the upper surface of the first rib

g If parӕsthesiӕ are elicited down the arm, the plexus has been contacted, and 15–20 ml of 2 per cent lignocaine can be injected to complete the block, after preliminary aspiration

h If no parӕsthesiӕ can be elicited, a cone of infiltration with its base on the first rib is carried out, using 20–30 ml of 1 per cent lignocaine

i A successful block is indicated by a sensory and motor paralysis of the arm usually accompanied by an ipsilateral Horner s syndrome

Hazards —

a Puncture of the dome of the pleura shown by aspirating air into the syringe

b Puncture of subclavian artery or vein, shown by the aspiration of blood into the syringe

5 **Wrist-block** —Use 10 c c of $\frac{1}{2}$ per cent lignocaine and extend to a cuff block, if need be with $\frac{1}{4}$ per cent solution

a An intradermal and subcutaneous infiltration, just above the wrist

b 5 ml of 1 per cent lignocaine injected lateral to the tendon of palmaris longus will block the median nerve

c 5 ml of 1 per cent lignocaine injected lateral to the tendon of flexor carpi ulnaris will block the ulnar nerve

d Infiltration on the anterolateral aspect of the wrist at the base of the thumb will block the terminal branches of the radial nerve

6 **Ring Block** —Infiltration of the tissues at the base of the fingers or toes in an annular manner will provide good analgesia for operations on the digits

made by the stiff extended middle and index fingers directed obliquely backwards and upwards As it passes into place the fingers slide very slightly (2–3 mm) to the right The needle is passed 1–1½ cm through the tissues and test-aspiration is done 5 ml of solution is injected, the needle being steadied by approximation of the extended fingers Again test aspiration is carefully done If no blood appears 30–40 ml of solution (½ per cent lignocaine) is injected without moving the needle Slight slowing of the pulse is usually noted as this proceeds

For gastric surgery it is now convenient to pass the needle into the loose tissues to the right of the cardia and inject 20 ml of solution This cuff of solution round the lower œsophagus provides an effective vagal block and renders traction on the cardia (for gastrectomy, Heller s operation or hiatus hernia repair) quite free from discomfort or reflex upsets

10 Extradural Blocks —Extradural blocks in general are not recommended Extradural sacral block has however, an occasional place in lower limb or anal surgery and cystoscopy, and has been used in obstetrics Alternative methods of local analgesia are however, available for all these (cuff block local infiltration, lignocaine jelly, instillation pudendal block, and local infiltration)

11 Stellate Block —This is a useful technique to test whether surgical removal of the ganglion will help in such conditions as causalgias Raynaud's disease etc, of the upper limb

a The patient lies with his head on a low pillow, turned to the side opposite to that which is being blocked

b Identify the interval between the two heads of the sterno-mastoid just above the sternoclavicular joint (*N B* —These muscle bellies may be made more prominent by asking the patient to flex his head against resistance)

c Pass a fine spinal needle vertically backwards to strike bone which should be in the region of C 7 transverse process

d Aspirate to exclude a puncture of the dome of the pleura or vessel, and inject 10–15 ml of 1 per cent lignocaine

e The onset of Horner s syndrome indicates a successful block i e (i) Ptosis, (ii) Meiosis (iii) Enophthalmos,

b Lumbar —

i Skin weals are raised opposite the upper edge of the spinous processes, two fingerbreadths from the midline

ii A fine spinal needle is passed vertically through these to strike the transverse process

iii Partly withdraw the needle and then pass it slightly upwards and inwards for 3 cm, to pass over the upper border of the transverse process

iv After aspiration, 10 ml of 1 per cent lignocaine is deposited

v For L 5 nerve, insert the needle through the same weal as for the L 4 nerve, but the needle is aimed slightly downwards, to slide off the lower border of the transverse process

Position of the Patient —For paravertebral injections the patient can be sitting up with his feet over the side of the table, or curled up on his side

8 **Intercostal Block** —

In the Mid axillary Line —

a The patient lies on his back, with the arm on an arm-rest at right angles to the body

b Weals are raised at the lower borders of the corresponding ribs

c A fine needle is passed through the weal, to contact the lower part of the rib, then carefully positioned at the lower border, so that the point lies in the region of the subcostal groove

d After aspiration 5–8 ml of 1 per cent lignocaine is injected

9 **Anterior Splanchnic Block** —This is performed usually by the surgeon when the upper abdomen is accessible The prepyloric zone is quietly pulled caudally and the left hand of the operator passes over the gastrohepatic omentum The liver is very gently lifted by a retractor The operator's middle finger slides upwards along the right border of the aorta, passing above the renal artery and comes to lie in a hollow between this vessel below the crus of the diaphragm laterally and above the aorta to the left The operator's index finger now lies on the aorta The needle (22 gauge 6 in) of the Pitkin syringe is slid into place along the groove

CHAPTER XIX

INTRAVENOUS THERAPY

BLOOD

Indications for the administration of blood are —

1 Hæmorrhage—to restore blood-volume

2 The restoration of oxygen carrying capacity, e g, in anæmias

3 To supply platelets, immune bodies, or leucocytes

Hæmorrhage —

1 *Acute* —Sufficient whole blood should be administered rapidly to raise the systolic blood-pressure to over 100 mm Hg It can then be replaced more slowly until the estimated loss has been replaced One pint of whole blood raises the hæmoglobin level by 5–8 per cent

2 *Chronic* —Hæmorrhage, e g leaking hæmorrhoids, metrorrhagia, etc, results in anæmia and is best replaced by packed cells, to avoid overloading the circulation One pint of packed cells raises the hæmoglobin by 10–16 per cent Signs of overloading the circulation are —

1 Congested neck veins

2 Crepitations at the lung bases No major operation should be performed with a hæmoglobin of less than 60–70 per cent, or delayed wound repair will result

Shock —The aim is to restore blood volume and blood-pressure

1 Where there is blood loss, use whole blood

2 In cases of trauma crush injuries, or burns, use plasma or plasma substitutes Sufficient blood or plasma should be given to maintain the blood pressure at 100 mm Hg systolic

Fresh and Stored Blood —Fresh blood is withdrawn from a donor placed in pint bottles containing 120 ml of disodium citrate, and stored at 2–4° C It can be kept for approximately three weeks before being used

(iv) Anhydrosis of the corresponding side of the face, (v) Sometimes dilatation of the conjunctival vessels

12 Fractures and Dislocations—Local analgesia has particular use in Colles' fracture in the elderly, but may be used for any limb fracture by free infiltration of muscles and tissues about the fracture site and injection into the fracture hæmatoma Quantities vary from 10–12 ml of 1 per cent lignocaine into the hæmatoma for Colles fracture, to 100–150 ml of ½ per cent solution for fracture of the femoral shaft or dislocation of the shoulder Often prompt infiltration before radiography or moving splinting, etc, prevents further shock and is itself a valuable resuscitation measure

Conclusion—*These notes can do no more than indicate* some techniques In practice simple infiltration, cuff or ring blocks, field blocks, and intercostal blocks suffice for almost every purpose

Local analgesia for major surgery demands co-operation of surgeon and nursing staff, understanding management of the patient by the anæsthetist, and adequate premedication It is however, one anæsthetic method of choice for all really bad-risk patients and for many of the doubtful cases, besides being for some operations a very simple and satisfactory method It is the *safest* of all anæsthetic methods Bleeding and shock are reduced and the recovery of patients is very smooth

There is also a large place for combinations of local analgesia with general anæsthesia But the beginner should master the essentials of analgesic technique and patient management using local analgesia alone Only thus can he ensure that in his combined techniques the local analgesia is really used and not a perfunctory gesture

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How to set up a Blood Transfusion—Using the M R C transfusion-giving set —

1 Remove the cap from the bottle

2 Unwrap the rubber tubing and without touching anything but the rubber cork, carefully insert cork and filter into the blood bottle

3 Hang the bottle on a stand and run blood through the rubber tubing to expel the air bubbles

4 Fix the patient's arm comfortably on a rest at an angle of no more than 80° to the body to avoid a brachial palsy Apply a pneumatic cuff or tourniquet to the upper arm, inflate to 70–90 mm Hg and insert the needle in a forearm vein Once in the lumen, pass it upwards for ½ in to avoid it pulling out during transfusion Avoid the veins near the wrist or antecubital fossa as movement here will cause the needle to spike through the vein

5 Fix needle and rubber tubing firmly with strapping

Needle drips should be used wherever possible It should rarely be necessary to cut down on a vein, except for prolonged transfusions

Miscellaneous Points—

1 Do not forget to remove the tourniquet, before deciding that the drip will not run

2 Watch the tip of the needle, to see that the infusion is not running into the tissues

3 If venospasm is the cause of stoppage 2 ml of 2 per cent procaine injected into the rubber tubing near the needle will overcome this It will also shift any small clot that may be in the needle (*N B*—Clamp the tubing behind the site of injection while carrying out this manœuvre)

4 *If the drip chamber fills up* —

a Clamp the rubber tubing above the chamber

b Carefully inject with a syringe just sufficient air into the tubing to clear the dropper, and lower the fluid level in the chamber Too much may result in an air embolism

5 The use of a Higginson syringe to speed up a drip by positive pressure cannot be too severely condemned More than one fatal case of air embolism has resulted by its use

The leucocytes, platelets, and immune bodies deteriorate in three days, so fresh blood should be used for —

1 Patients suffering from blood dyscrasias

2 Patients suffering from anæmia associated with sepsis

3 Patients suffering from hæmophilia or purpuras

Rh-negative Blood[1]—Ideally Rh negative blood should be given to all Rh-negative patients For practical purposes give it —

1 For multiple transfusions to an Rh-negative patient, or if the patient has had a previous transfusion

2 To Rh-negative females in the child-bearing age

3 Mothers of infants showing signs of hæmolytic disease

4 Infants affected with hæmolytic disease

Packed Cells—These are prepared by decanting or siphoning the supernatant plasma under aseptic conditions They must be used within 24 hours of preparation and should not be shaken during transportation or hæmolysis will occur The drip should be run at a slightly higher rate than for whole blood owing to its greater viscosity

Indications —

1 To raise the hæmoglobin level rapidly

2 In anæmias associated with œdema congestive heart failure, etc

Blood Transfusion—With the pathological services now so well organized it rarely falls to the lot of the anæsthetist to carry out typing and cross-matching of blood In an emergency however, he should be able to carry out a simple direct cross matching test between donor and recipient

Slide Technique —

1 Take 1–2 drops of the donor s blood and dilute with 1–2 c c of normal saline

2 Place 2–3 drops of the recipient s serum on a clean glass slide

3 Add 1 drop of the saline suspension of cells and mix using a sterile loop

4 Leave for 10–15 minutes and examine macroscopically and microscopically for evidence of agglutination If none is present the blood is compatible

Transfusion Reactions[*]—

1 *Febrile Reactions*—Often associated with rigors May be due to unclean apparatus, foreign proteins, or pyrogens in the distilled water

2 *Hæmolytic Reactions*—Due to incompatible or old blood

Symptoms—

a Rigors

b Pain in the loins,

c Hæmaturia,

d Jaundice

3 *Allergic Reactions*—Urticaria or localized œdema Usually respond well to adrenaline, or antihistaminics

Plasma and Serum—These are stored in the dry state, when they can be kept indefinitely They are reconstituted for use by the addition of 400 ml of distilled water Liquid plasma is unstable on storage owing to clot formation and serum owing to calcium soap formation

Serum—Is formed from clotted blood, contains 7 per cent protein, and no fibrinogen

Plasma—Is formed from citrated blood, contains 4–5 per cent protein, and fibrinogen

Preparation Pooled serum is used, as it has a low agglutinin content, and can therefore be given to any blood group recipient The pools are kept small (8–10 donors) to reduce the risk of homologous serum jaundice If concentrated plasma is required, half the quantity of water can be used to reconstitute it It should be made up just before use, to reduce the possibility of air-borne contamination Hæmoglobin estimations should be done to ensure that there is no marked hæmodilution

Uses—

1 In shock associated with surgery or trauma,
2 Crush injuries
3 Burns
4 In an emergency until blood is typed

PLASMA SUBSTITUTES

Many substances were tried during the last war to replace plasma which was in short supply The two best are —

6 The arm should not be left out on an armboard if the patient is in the Trendelenburg position, as it tends to hyper-abduct It is better folded across the chest

7 If glucose solutions are to follow the blood, it is best to run normal saline through the tubing between the two, to avoid clogging of tubing or veins

Cut-down Transfusion Technique—

1 Inject 2–3 ml of 1 per cent lignocaine over the selected vein

2 Incise the skin and fascia transversely with a scalpel

3 Using mosquito forceps, dissect bluntly in the line of the vein until it comes into view Clean the vein of fatty tissue

Fig 74—Frankis Evans needle cannula (Medical and Industrial Equipment Ltd)

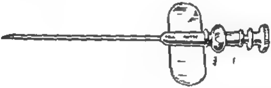

Fig 75—Guest's needle cannula (John Bell & Croyden)

4 Pass the forceps under the vein and draw back a double strand of catgut beneath it

5 Tie off the lower catgut, and use the upper one as a tractor for the vein

6 Carefully cut a V incision in the vein with scissors or scalpel and grasp the tip of the V with mosquito forceps

7 Using these to open the incision carefully insert the cannula, and tie the upper catgut firmly around vein and cannula

8 Close the skin incision with a nylon suture, and strap cannula and tubing in place

A good alternative to cutting down is the use of the various needle cannulæ, e g, Frankis Evans and Guest's (*Figs* 74 75) These can be inserted as for a needle, and the trochar withdrawn to leave the cannula in position

Glucose and Saline Solutions [5]—

1 *Normal Saline*—Used to replace salt loss in cases of intestinal obstruction, perforated ulcer, pyloric stenosis, etc

2 *Bart's Solution*—4 3 per cent glucose in 1/5 normal saline, used particularly in children and the elderly to avoid overloading with sodium chloride

3 *Glucose Solution*—Five per cent

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1 **Dextran**[3]—This is a polysaccharide, formed by bacterial action polymerizing sucrose The dextran chains are 200,000 glucose units, with a molecular weight of 40 million They are reduced by partial hydrolysis, for use as blood-plasma substitutes to a value around M W 70,000–100,000 If the molecular weight is too small, the substance is excreted too easily If it is too large, it will damage the kidneys It is used as a 6 per cent solution in normal saline

Actions —

a One-third disappears from the blood-stream in 24 hours

b Only 5 per cent remains after one week

c 25 per cent is excreted in the urine The fate of the rest is at present unknown It may be stored in the reticulo-endothelial system

d It increases the E S R

e It interferes with blood typing, hence the patient *MUST* be typed before the infusion commences

f It may cause anaphylactic reactions

g It may cause an accumulation of fluid in the intestinal lumen, and should therefore be used cautiously in intestinal obstruction

h It can be autoclaved

2 **Plasmosan** (polyvinyl pyrrolidone)[4]—Made by chemical synthesis It is a water-soluble white powder It is made up in a sterile 3 5 per cent solution with sodium potassium, calcium and magnesium in the same proportions as in plasma The average molecular weight is slightly less than dextran

Actions —

a Stable and can be autoclaved

b Exact fate is unknown but seems to remain in the blood stream till excreted

c 75 per cent excreted in the urine

d Increases the E S R but has no effect on clotting time bleeding time or on blood typing

e Non-toxic and non antigenic

In view of the fact that the exact fate of these two substances is not yet fully worked out it is probably unwise to give more than 3–4 pints to any one patient

Other solutions used for intravenous therapy are —

2 Deliberate Hypotension—To produce this, a total sympathetic block is aimed at, by (*a*) a total spinal block or an extradural block, or (*b*) a chemical block using pentamethonium or hexamethonium drugs

Theory—The protagonists of these techniques maintain that, with the patient horizontal, there is an adequate circulation at a level of 60 mm Hg systolic if —

a The blood is well oxygenated,

b Vasodilatation has occurred

Indications—The use of hypotension is indicated in cases where the blood loss may be excessive, e g, abdominoperineal resection, or where the blood hampers the surgeon, e g, maxillofacial and neurosurgery

a Total Spinal—This technique, which has been perfected by Griffiths and Gillies, of Edinburgh, is as follows —

A total sympathetic block up to T 1 is aimed at, using a dilute solution of procaine (0 2 per cent), which knocks out the sympathetic fibres, while sparing the motor fibres to the intercostal muscles

i The patient is induced with thiopentone and intubated

ii Lumbar puncture is performed, between L 2 and 3, and 150–200 mg of procaine, dissolved in 2–3 ml of C S F, is introduced

iii The patient is then placed in a steep Trendelenburg position and the operation commenced If the respiration becomes inadequate it is controlled

iv By this means the authors obtained ideal operating conditions for such difficult operations as thoracolumbar sympathectomy etc

b Methonium Drugs—Consist of two quaternary ammonium compounds, separated by methylene groups

i The lower series produces ganglionic block, without previous excitation and without side-effects

ii They act at the synapse yet without interfering with the acetylcholine mechanism

iii They affect in order of preference —

α The parasympathetic to the salivary gland

β The superior cervical ganglia

CHAPTER XX

HYPOTENSION

MANY different methods have been used by the anæsthetist to obtain a comparatively bloodless field for the surgeon

1 In the extremities by application of tourniquets

2 By positioning the patient, e g, anti-Trendelenburg position for head and neck operations

3 By the pre operative injection of dilute adrenaline solution, e g, in thyroidectomy

4 By deep general anæsthesia, e g deep ether or chloroform, by depressing the cardiovascular system, lowers the blood-pressure

5 By avoiding faults in technique, which cause a rise in blood-pressure e g

a Avoiding minor respiratory obstruction

b Avoiding carbon dioxide retention

6 By avoiding the use of cyclopropane (any light general anæsthetic may cause troublesome bleeding)

7 By avoiding the use of relaxants, which, with controlled respiration, will cause more oozing than usual

Recently the problem of the bloodless field has been attacked from several aspects —

1 Production of Vasoconstriction.—Gardner in 1946, produced vasoconstriction by arteriotomy, and restored the blood at the end of the operation He cannulated the radial artery and drew off approximately 500 ml of blood into a heparinized reservoir The blood pressure was lowered to 80-90 systolic and the blood was restored to the circulation by gravity at the end of the operation The radial artery was then ligated causing temporary blueness of the fingers in some cases, but no lasting effect This technique was used mainly in neurosurgery, and posture played no part as the bloodless field was caused by vasoconstriction

v A Gordh needle or intravenous drip is advisable, for direct access to a vein

vi Blood is required for major cases, as hypotensive patients tolerate blood loss poorly

vii An assistant to take serial blood-pressure readings is a help Once the anæsthetic is stopped, the blood-pressure tends to rise, though it may take up to 6 hours to reach its pre-operative level

Antidote —

i Methylamphetamine is not a physiological antidote as it causes a peripheral vasoconstriction which may wear off, and result in a secondary blood-pressure fall

ii A better method is to return the patient to the ward on a tilting trolley, head down, until the blood-pressure reaches its pre-operative level (*N B* —Post-operative oliguria, due to lowered blood-pressure, may prolong the action of the drug [2, 3])

Miscellaneous Points —

i There is a high percentage failure rate (30 per cent of cases approximately) so that it is important to obtain the required fall in pressure with the initial dose of the drug

ii An attempt to reduce the risks of hypotension and make it more controllable has been made by the use of a negative-pressure box applied to the lower limbs (Saunders) It enables smaller doses of hexamethonium to be used effectively

iii A shorter acting drug Arfonad has recently been tried administered as an intravenous drip (1 mg /ml at a rate of 2–3 mg per minute) The degree of hypotension varies with the drip speed, and the blood pressure rises soon after the drip is stopped [4]

iv In cases resistant to hexamethonium potentiation by means of procaine amide (0 5–1 g) has been tried with success It should be used with great caution and a blood-drip should be running in case of profound hypotension [5]

Complications —The following complications have occurred, using hypotensive techniques —

1 Sudden death due to coronary insufficiency
2 Cranial embolism and thrombosis
3 Blindness [6]

γ Visceral ganglia

δ Vagal ganglia

iv The hexamethonium group, but not the pentamethonium is liable to cause ileus

Wyman,[1] who has had considerable experience with these drugs, makes the following points —

i The initial dose must be sufficient to produce the required fall in blood-pressure, for the duration of the operation

ii Once a total sympathetic block is produced, there should be no further blood pressure fall with increased dose

iii For a dry field, a blood-pressure of 45–60 mm Hg systolic is required

iv In patients with a labile blood-pressure it is easy to produce hypotension In young, fit males with a stable blood pressure, the drugs produce a tachycardia but little fall in blood pressure

v The fall in blood pressure following thiopentone induction is a guide to the reactivity of the patient

Contra-indications to the use of hexamethonium —

i Anoxia (if a hypoxic episode occurs during induction, it is unwise to use it)

ii Heart disease or marked atheroma

iii Previous cerebrovascular disease

iv Established shock

v Established hæmorrhage

Technique —

i A full pre operative examination of the patient is required to exclude contra indications

ii The patient should be induced on a tilting trolley

iii The blood pressure is taken the patient induced with thiopentone intubated, and the blood pressure taken again

iv According to the sensitivity of the patient, a dose of hexamethonium is given

Dose 25–250 mg (Wyman)
10–50 mg (Enderby)

The discrepancy between these dosages is explained by the fact that Wyman keeps his patients horizontal, while Enderby uses posture to enable him to use smaller doses of hexamethonium

CHAPTER XXI

ANTIHISTAMINICS IN ANÆSTHESIA

THE amino derivatives of phenothiazine are a group of drugs whose specific antihistaminic, or anti Parkinsonian effects, have been studied for about ten years In 1948 Winter compared the action of different antihistaminics on hexabarbitone anæsthesia in mice, and found that promethazine hydrochloride (Phenergan) had a marked potentiating effect In April 1950 Laborit published his first account of promethazine in general anæsthesia His results were later confirmed by Huguenard and Mandeleer

Although promethazine was the most effective potentiator of anæsthetics known at that time, its action was still not sufficient to give really decisive therapeutic results It was later found that 4560 R P or chlorpromazine had a more potent central action

Pharmacological Properties —

1 *Promethazine Hydrochloride (Phenergan)* [1]—

a It acts as a hypnotic and potentiates the action of similar drugs

b It is spasmolytic and anticonvulsant

c It has slight relaxant properties

d It reduces basal metabolism

e It is a potent anti emetic

2 *Chlorpromazine Hydrochloride (Largactil)* - [3]—

a It has an inhibitory action on the whole autonomic nervous system It is more marked on the sympathetic while the action on the parasympathetic takes the form of a potentiation of vagolytic substances

b It is a potent adrenolytic and reduces the hypertension produced by adrenaline

c It also reduces the hypotension and bradycardia produced by an injection of acetylcholine

A recent questionnaire sent to British anæsthetists using hypotensive techniques revealed that there is an overall mortality of one in 450–500. Hence it is a technique which at present should be reserved for cases in which a bloodless field is essential for the performance of the operation.

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Technique —

a Premedication as in (1)

b An intravenous infusion of a 'lytic cocktail' consisting of a mixture of promethazine, chlorpromazine, and pethidine, which is commenced an hour before operation

c Additional general anæsthesia, using reduced dosages of anæsthetic agents

3 *Artificial Hibernation* [5]—

a Operations on otherwise inoperable or incurable cases

b Shock, hyperthermia of central origin, tetanus

Technique Premedication as in (1)

a Addition of lytic cocktail'

b Generalized cooling (after production of the autonomic blockade)

Hazards of artificial hibernation —

a No morphine should be given with chlorpromazine, as its potentiating effect may cause renal irritation

b Sympatheticommimetic agents may cause convulsions of central origin

c Hypotensive agents may cause a long-lasting hypotension

d If the body temperature falls below 30° C ventricular fibrillation may occur

The successful use of artificial hibernation requires appropriate technical facilities and continuous observation of pulse, blood pressure, respiration and temperature Expert personnel are required, but in selected cases it enables otherwise inoperable cases to be attempted with a reasonable chance of success

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d It produces a postural hypotension, but not as marked as with methonium compounds

e It is hypnotic, hypothermic, antipyretic, and anti convulsant

f Its anti emetic properties are purely central and there is no effect on vomiting caused by gastric irritation

g It potentiates the action of general anæsthetics and analgesics

h It is thought to potentiate the action of relaxants

i It is thought to produce a chemical lobotomy, resulting in a carefree attitude on the part of the patient

j Its peripheral actions include a mild antihistaminic activity, a potentiation of local analgesia, and possibly the prevention of hæmorrhage and traumatic shock The shock resistant state may be due to its antihistaminic action, through the prevention of capillary hyperpermeability, or it may be due to sympathetic blockade

Practical Applications—For practical purposes, the inhibition of autonomic function associated with these drugs can be utilized in three ways —

1 *Premedication*—Here the aim is to produce a feeling of well-being in the patient a prolonged sedative and analgesic effect and to facilitate subsequent anæsthesia

Indications For operations of moderate severity

Technique The spacing and dosage of the drugs has not been fully worked out but the following is given as a specimen technique —

a *Evening before operation* —

8 p m 50 mg chlorpromazine (oral)
10 p m 50 mg chlorpromazine (oral)
+ butobarbitone gr 3

b 2 *hours pre-operatively* —

50 mg chlorpromazine intramuscularly

c 1 *hour pre operatively* —

Pethidine 50–100 mg + Atropine gr $\frac{1}{100}$

N B—For local and spinal analgesia the pethidine and atropine can be omitted

2 *Potentiated Anæsthesia* (Partial Hibernation)[4]—

Indications Major surgery involving the liability of shock

Zone 2 Fairly Dangerous —The area for approximately 1 ft around Zone 1

Zone 3 Still Dangerous —The area for 3 ft around Zone 1

Perspex and *Nylon* are particularly liable to store static electricity, as they are poor conductors

Cotton is a good conductor when moist, but poor when dry

Safety Measures —

a Incorporation of a colloidal graphite in all the rubber sheets, tubing, masks, rebreathing bags, endotracheal tubes, pharyngeal airways, etc [5]

b Earthing of all trolleys, machines, operating tables, etc

c Ionization of the air, to dissipate static charges, has been suggested A radio active material in the air intake e g, a radium plaque emitting β rays, protected by a copper screen, so that the radiation is not harmful to the theatre personnel, has been tried

d Increasing the humidity of the theatre (*N B* —Materials should be semi-conducting only, to allow a slow dissipation of the static charge If they are fully conducting it may be possible to get a sudden fatal discharge to earth)

2 **Electrical Apparatus** —Sparking is always possible from faults developing in apparatus in use by the surgeon or theatre staff e g —

a X-ray machines

b Electric cautery and coagulation

c Cystoscopes and endoscopic instruments

d Electric suction machines respirators, electric lights, etc

Safety Measures —

a The use of non explosive anæsthetics whenever electrical apparatus is in use

b The use of safety non sparking motors in respirators etc

c The use of safety wall-plugs for all electrical equipment, and the use of an earthing wire in all circuits

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CHAPTER XXII

THE EXPLOSION RISK

ANÆSTHETISTS are becoming increasingly aware of the explosion risks[1, 2] incurred during the administration of the explosive or inflammable anæsthetics The drugs at risk are —

1 **Ether and Divinyl Ether** —

a Ether vapour, being heavier than air, falls to the floor and may burn with a cool flame if a source of ignition is present

b Mixtures of gas, oxygen, and ether are particularly dangerous owing to the activated oxygen liberated by the breakdown of the nitrous oxide Exhaled ether is said not to be explosive but a good five minutes should elapse between turning off the ether and applying diathermy, etc [3]

2 **Ethyl Chloride** —Is explosive in an oxygen mixture The fluid burns if ignited

3 **Cyclopropane** —Is more explosive than ether, and should not be used even in a closed circuit, wherever diathermy X rays etc, are being used

4 **Oxygen** — Any source of ignition will burn more brightly in the presence of oxygen under pressure No oil or grease should be used on oxygen cylinders owing to the danger of explosion

Causes of Explosion and Methods of Prevention —

1 **Static Electricity** —Static electricity is produced whenever two different surfaces are rubbed against each other The movements of a rebreathing bag, the removing of a blanket, etc from a patient may build up a dangerously high charge of static electricity [4]

In the theatre we can, for practical purposes divide the risks from static electricity into three zones —

Zone 1 *Dangerous* —

a The machine and its environs

b Masks tubing patient etc

c Operating table

c Tracheobronchial toilet is carried out to remove excess secretions

d The fluid balance is maintained, if necessary, by intravenous fluids

e The use of analeptics is controversial On the whole they are probably best avoided, as the barbiturates have usually exerted their maximum effect on the C N S by the time the patient is admitted

4 *Coma following Head Injuries*—The anæsthetist can emphasize to his colleagues the value of early tracheotomy and adequate tracheobronchial toilet in preventing fatal lung complications in these cases

5 *Status Epilepticus*—A life-saving measure where the patient arrives cyanosed and exhausted from repeated fits, is the administration of just sufficient thiopentone to stop the convulsions This should be followed with adequate ventilation of the patient with oxygen until normal respiration is resumed

6 *Tetanus*[2, 3]—Previously, control of tetanic spasms has been attempted by the use of heavy sedation Since the advent of relaxants however, the advantage of controlling the spasms by the use of these peripheral blocking agents has been realized Difficulties were first, there was such a small margin between controlling spasm and causing respiratory arrest, and, second the intensity of the spasms varied from moment to moment Myanesin, in the form of an elixir has been tried (dose ½–1 g 4–6 hourly) It has a good respiratory sparing action, but must be given via a Ryle s tube as it has a local analgesic effect on the oral mucous membrane and may result in aspiration of fluids into the tracheobronchial tree Smith and Thorne have reported success using gallamine triethiodide intravenously The answer probably lies in the use of a short-acting relaxant such as suxamethonium in the form of a drip which can be turned on as the spasms occur

Poliomyelitis[4]—Anderson and Ibsen have shown the valuable part anæsthetists can play in the management of a poliomyelitis epidemic with respiratory paralysis In reporting on the 1952 outbreak in Denmark they made the following points —

CHAPTER XXIII

THE EXPANDING ROLE OF THE ANÆSTHETIST

IN most modern hospitals the anæsthetic department carries out many duties besides the actual administration of anæsthetics It controls the administration of the blood transfusion service, and the resuscitation and immediate post operative care of the patient Premedication and the selection of the best type of anæsthetic to suit the patient, are arranged in consultation with the surgeons and physicians concerned There are many ways in which the anæsthetist, armed with a good knowledge of physiology and pharmacology, and experienced in dealing with cardiorespiratory conditions can be of help to his colleagues

Emergencies —

1 *Drownings* —The anæsthetist armed with his emergency trolley (Chap I), is well qualified to carry out the initial treatment when these patients arrive in the casualty department If the heart is still beating the patient is intubated, a suction catheter passed down into the main bronchi and the water sucked out Artificial respiration is carried out using intermittent positive pressure with oxygen from an anæsthetic machine or resuscitator Excess fluid is sucked out from time to time as required

2 *Electric Shock* —A similar technique is used in these cases Suction is only required if there are excess secretions in the tracheobronchial tree

3 *Barbiturate Poisoning*[1]—The anæsthetist s experience in caring for the unconscious patient is often of use in treating these patients The following points are essential for success after an initial stomach washout —

a The patient must be adequately ventilated, if respiration is grossly depressed or oxygen supplied to combat cyanosis

b Two-hourly turning is instituted to combat hypostatic pneumonia and antibiotics are given for the same reason

mistakes in technique are not to be increased Each new advance is greeted with enthusiasm as the answer to all anæsthetic problems, and in time settles down to its true place in the anæsthetist's armamentarium We should endeavour to maintain a sense of proportion, and keep our techniques as simple as possible for the type of operation to be performed, reserving the more complicated methods for those cases where their use is justified Only thus will we maintain the high aim of the anæsthetist—*in somno securitas*

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1 Close co operation between anæsthetists and physicians was essential

2 Patients liable to develop respiratory complications were transferred to special wards for observation, and recordings of blood pressure, pulse and respiration were carried out

3 Tracheotomies were performed early, using cuffed endo tracheal tubes

4 Negative-pressure respirators were unsatisfactory as —

a They tended to suck secretions further into the tracheo-bronchial tree

b Access to the patient was difficult in the box types

5 Intermittent positive-pressure ventilation was carried out using 50 50 nitrogen and oxygen to avoid oxygen poisoning from too high a percentage of the latter

6 A cuffed tube was inserted through the tracheotomy opening and the patient ventilated, using a soda-lime canister and reservoir bag (manual compression or mechanical pump)

7 Secondary shock was treated where necessary

Advantages of Positive-pressure Respiration —

1 Access to the patient is easier, one can follow the thoracic movements, take radiographs and superintend breathing exercises

2 Management of the tracheotomized patient is easier, and secretions can be sucked out by catheter Bronchoscopy can be performed if required

Therapeutics —Many hospitals now run 'pain clinics', where regional blocks or local infiltrations are performed for various painful conditions Diagnostic or therapeutic blocks may be performed pre operatively, e g, stellate ganglion block for vasospastic disease of the upper limb, causalgias, etc, or a lumbar sympathetic block to determine the effectiveness of a lumbar sympathectomy

The Future —With the introduction of relaxants, hypotensive drugs, and now antihistamines anæsthesia has reached the stage where we control not only the patient's respiratory and cardiovascular systems but also his vital processes The swing of the pendulum has tended to make the specialty more and more complicated and demands much more of the anæsthetist if the mortality and morbidity from

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